



PHASE II

**FIRE RESISTANCE TESTING OF
BULKHEAD AND DECK PENETRATIONS**

David E. Beene, Jr.

U.S. Coast Guard
Marine Safety Laboratories
Marine Fire and Safety Research Division
Avery Point, Groton, CT 06340 - 6096

Jack H. Howes

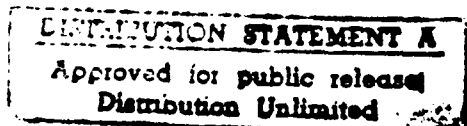
Canadian Coast Guard
Canada Building
Ottawa, Canada, K1A 0N7

Allen Penn

U.S. Coast Guard
Marine Technical and Hazardous Materials Division
Washington, D.C. 20593-0001

**Final Report
December 1988**

Document is available to the U.S. public through
The National Technical Information Service,
Springfield, Virginia 22161



Prepared for:

**United States Coast Guard
Office of Marine Safety, Security,
and Environmental Protection
Washington, D.C. 20593-0001**

AD-A211 235

DTIC
ELECTE
JUL 07 1989
S D D

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

This report does not constitute a standard, specification or regulation.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

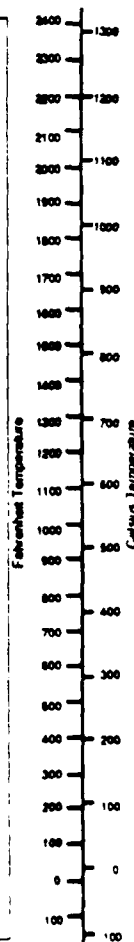
Technical Report Documentation Page

| | | | | | |
|---|--|---|--|---|--|
| 1. Report No. CG-M-3-89 | | 2. Government Accession No. | | 3. Recipient's Catalog No. | |
| 4. Title and Subtitle PHASE II - FIRE RESISTANCE TESTING OF BULKHEAD AND DECK PENETRATIONS | | | | 5. Report Date December 1988 | |
| | | | | 6. Performing Organization Code 3308.31 | |
| | | | | 8. Performing Organization Report No. CG-MFSRD-64 | |
| 7. Author(s) David E. Beene, Jr., Jack H. Howes, and Allen Penn | | | | | |
| 9. Performing Organization Name and Address Marine Fire and Safety Research Division Marine Safety Laboratories United States Coast Guard Avery Point, Groton, CT 06340-6096 | | | | 10. Work Unit No. (TRAIS) | |
| | | | | 11. Contract or Grant No. | |
| 12. Sponsoring Agency Name and Address Marine Technical and Hazardous Materials Division U.S. Coast Guard Department of Transportation Washington, D.C. 20593 Canadian Coast Guard Canada Building Ottawa, Canada K1A 0N7 | | | | 13. Type of Report and Period Covered FINAL | |
| | | | | 14. Sponsoring Agency Code | |
| 15. Supplementary Notes Testing performed by Underwriters Laboratories in Chicago, Illinois, under joint technical direction of the U.S. Coast Guard Marine Fire and Safety Research Division and the Canadian Coast Guard. | | | | | |
| 16. Abstract The U.S. Coast Guard and the Canadian Coast Guard conducted a series of tests to obtain information on the passage of flame, smoke, and heat through penetrations in deck assemblies. Class A-0 deck assemblies consisted of a penetrant passing through a 36 x 36 x 3/16 inch (91.4 x 91.4 x 0.5 cm) steel plate whereas Class A-60 deck assemblies consisted of the penetrant, the steel plate, and approved structural insulation attached to the penetration assembly. All testing was carried out by Underwriters Laboratories in accordance with UL 1479 Standard for Fire Tests of Through-Penetration Firestops. Underwriters Laboratories' 1-meter furnace was used for all fire tests. Eighteen combinations of penetration types were evaluated in 38 fire tests. Eight penetrations were tested for a Class A-0 rating and thirty penetrations were tested for a Class A-60 rating. Nine of those tested were insulated on the fire side, eighteen were insulated on the non-fire side, and three were only partially insulated on different sides of the steel plate. Six out of eight penetrations passed the requirements for a Class A-0 rating. Four out of nine penetrations insulated on the fire side passed the requirements for a Class A-60 fire rating while all eighteen penetrations insulated on the non-fire side failed the requirements for a Class A-60 rating. Test results demonstrate that ASTM E-814 or UL 1479 should be considered as the fire resistance performance test for approving penetration designs. This testing identified penetrations which could be used as design guidelines. | | | | | |
| 17. Key Words penetrations, fire stops, bulkhead, through-penetrations, deck | | | | 18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161 | |
| 19. Security Classif. (of this report) UNCLASSIFIED | | 20. SECURITY CLASSIF. (of this page) UNCLASSIFIED | | 21. No. of Pages | |
| | | | | 22. Price | |

Conversions to Metric Measures

When you know (symbol) Multiply by To find (symbol)

| Length | | |
|---|------------|---|
| inches (in) | 2.540 | centimeters (cm) |
| feet (ft) | 30.48 | centimeters (cm) |
| feet (ft) | 0.3048 | meters (m) |
| Area | | |
| square inches (in ²) | 6.452 | square centimeters (cm ²) |
| square feet (ft ²) | 929.0 | square centimeters (cm ²) |
| square feet (ft ²) | 0.09290 | square meters (m ²) |
| Volume | | |
| fluid ounces, US (fl oz) | 29.57 | milliliters (ml); cubic centimeters (cm ³) |
| gallons, US liquid (gal) | 3.785 | liters (l) |
| cubic feet (ft ³) | 0.02832 | cubic meters (m ³) |
| cubic yards (yd ³) | 0.7646 | cubic meters (m ³) |
| Mass (weight) | | |
| ounces, avoirdupois (oz) | 28.35 | grams (g) |
| pounds (lb) | 0.4536 | kilograms (kg) |
| Density | | |
| pounds per cubic inch (lb/in ³) | 27.68 | grams per cubic centimeter (g/cm ³) |
| pounds per cubic foot (lb/ft ³) | 16.02 | kilograms per cubic meter (kg/m ³) |
| Pressure | | |
| pounds per square inch (psi) | 6895 | pascals (Pa); newtons per square meter (N/m ²) |
| pounds per square inch (psi) | 0.0703 | kilograms per square centimeter (kg/cm ²) |
| pounds per square inch (psi) | 51.71 | millimeters of mercury (mm Hg) at 0°C |
| pounds per square inch (psi) | 0.06895 | bars (10 ⁵ N/m ²) |
| inches of water (in H ₂ O) at 60°F | 1.867 | millimeters of mercury (mm Hg) at 0°C |
| inches of water (in H ₂ O) at 60°F | 248.9 | pascals (Pa) |
| inches of water (in H ₂ O) at 60°F | 0.002489 | bars (10 ⁵ N/m ²) |
| inches of mercury (in Hg) at 32°F | 3386 | pascals (Pa) |
| inches of mercury (in Hg) at 32°F | 0.03386 | bars (10 ⁵ N/m ²) |
| Energy | | |
| British thermal units (Btu) | 1055 | joules (J); newton-meter (Nm) |
| British thermal units (Btu) | 0.2520 | kilocalories (kcal) |
| Thermal Conductance | | |
| Btu / hr · ft ² · °F | 0.0001356 | calories / sec · cm ² · °C |
| Btu / hr · ft ² · °F | 0.4862 | calories / hr · cm ² · °C |
| Btu / hr · ft ² · °F | 0.0005678 | watts / cm ² · °C |
| Heat Flow | | |
| Btu / hr · ft ² | 0.00007535 | calories / sec · cm ² |
| Btu / hr · ft ² | 0.2712 | calories / hr · cm ² |
| Btu / hr · ft ² | 0.0003154 | watts / cm ² |



Conversions from Metric Measures

When you know (symbol) Multiply by To find (symbol)

| Length | | |
|--|----------|---|
| millimeters (mm) | 0.03937 | inches (in) |
| centimeters (cm) | 0.3937 | inches (in) |
| meters (m) | 39.37 | inches (in) |
| Meters (m) | 3.281 | feet (ft) |
| Area | | |
| square centimeters (cm ²) | 0.1550 | square inches (in ²) |
| square centimeters (cm ²) | 0.001076 | square feet (ft ²) |
| square meters (m ²) | 1550 | square inches (in ²) |
| square meters (m ²) | 10.76 | square feet (ft ²) |
| square meters (m ²) | 1.196 | square yards (yd ²) |
| Volume | | |
| milliliters (ml) | 0.03381 | fluid ounces, US (fl oz) |
| liters (l) | 0.2642 | gallons, US liquid (gal) |
| liters (l) | 0.03531 | cubic feet (ft ³) |
| cubic centimeters (cm ³) | 0.06102 | cubic inches (in ³) |
| cubic meters (m ³) | 35.31 | cubic feet (ft ³) |
| cubic meters (m ³) | 1.308 | cubic yards (yd ³) |
| Mass (weight) | | |
| grams (g) | 0.03527 | ounces, avoirdupois (oz) |
| grams (g) | 0.002205 | pounds (lb) |
| kilograms (kg) | 2.205 | pounds (lb) |
| Density | | |
| grams per cubic centimeter (g/cm ³) | 0.03613 | pounds per cubic inch (lb/in ³) |
| kilograms per cubic meter (kg/m ³) | 0.06243 | pounds per cubic foot (lb/ft ³) |
| Pressure | | |
| pascals (Pa); newtons per sq. meter (N/m ²) | 0.000145 | pounds per square inch (psi) |
| bars (10 ⁵ N/m ²) | 14.50 | pounds per square inch (psi) |
| kilograms per square centimeter (kg/cm ²) | 14.22 | pounds per square inch (psi) |
| millimeters of mercury (mm Hg) at 0°C | 0.01934 | pounds per square inch (psi) |
| millimeters of mercury (mm Hg) at 0°C | 0.5357 | inches of water (in H ₂ O) at 60°F |
| bars (10 ⁵ N/m ²) | 401.8 | inches of water (in H ₂ O) at 60°F |
| pascals (Pa) | 0.00402 | inches of water (in H ₂ O) at 60°F |
| pascals (Pa) | 0.000295 | inches of mercury (in Hg) at 32°F |
| bars (10 ⁵ N/m ²) | 29.53 | inches of mercury (in Hg) at 32°F |
| Energy | | |
| kiljoules | 0.9478 | British thermal units (Btu) |
| kilocalories | 3.968 | British thermal units (Btu) |
| Thermal Conductance | | |
| calories / sec · cm ² · °C | 7373 | Btu / hr · ft ² · °F |
| watts / cm ² · °C | 1761 | Btu / hr · ft ² · °F |
| Heat Flow | | |
| calories / sec · cm ² | 13270 | Btu / hr · ft ² |

TABLE OF CONTENTS

| | <u>Page</u> |
|--|-------------|
| 1.0 OBJECTIVES..... | 1 |
| 2.0 BACKGROUND..... | 1 |
| 3.0 APPROACH..... | 2 |
| 4.0 TEST METHOD..... | 3 |
| 5.0 PROCEDURES..... | 7 |
| 5.1 Test Assembly Construction..... | 12 |
| 5.2 Fire Exposure Test..... | 13 |
| 5.3 Hose Stream Test..... | 16 |
| 6.0 RESULTS AND DISCUSSION..... | 16 |
| 6.1 Class A-0 Penetrations..... | 16 |
| 6.2 Class A-60 Penetrations..... | 27 |
| 7.0 CONCLUSIONS..... | 47 |
| 8.0 RECOMMENDATIONS..... | 52 |
| 8.1 Penetration Designs..... | 52 |
| 8.2 Approval Test Procedures..... | 52 |
| REFERENCES | R-1 |
| APPENDIX A - Description of Sample Penetrations | A-1 |
| APPENDIX B - UL 1479, Standard for Fire Tests of Through- Penetration Firestops | B-1 |
| APPENDIX C - UL Test Report | C-1 |

| | |
|--------------------|-------------------------------------|
| Accession For | |
| NTIS CRA&I | <input checked="" type="checkbox"/> |
| DTIC TAB | <input type="checkbox"/> |
| Unannounced | <input type="checkbox"/> |
| Justification | |
| By | |
| Distribution / | |
| Availability Codes | |
| Dist | Avail and/or Special |
| A-1 | |

LIST OF ILLUSTRATIONS

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 1. Piping Penetrations..... | 4 |
| 2. Ventilation Ducting Penetrations..... | 5 |
| 3. Electrical Cabling Penetrations..... | 6 |
| 4. Class A-0 Construction..... | 9 |
| 5. Class A-60 Construction Insulated on Fire Side..... | 10 |
| 6. Class A-60 Construction Insulated on Non-Fire Side.... | 11 |
| 7. UL Test Furnace..... | 14 |
| 8. Standard Time-Temperature Curve versus Penetration Time-Temperature Curves..... | 15 |
| 9. Class A-0 Test Failures..... | 24 |
| 10. Temperatures on Copper Penetrant (D10/A-0) During Class A-0 Test..... | 26 |
| 11. Temperatures on PVC Penetrant (D14/A-0) and Copper Penetrant (D10/A-0) During Class A-0 Test..... | 28 |
| 12. Temperatures on Ventilation Ducts (D17/A-0, D25/A-0, D26/A-0) During Class A-0 Tests..... | 29 |
| 13. Temperatures on Electrical Cable Penetrations (D22/A-0, D23/A-0, D24/A-0) During Class A-0 Test..... | 30 |
| 14. Temperatures on Steel Penetration Failure (D3/A-60U) During Class A-60 Test..... | 32 |
| 15. Temperatures on Copper Penetration Failures (D4/A-60U, D5/A-60U) During Class A-60 Test..... | 33 |
| 16. Temperatures on Copper Penetration Failures (D6/A-60U, D9/A-60U) During Class A-60 Test..... | 34 |
| 17. Temperatures on Copper Penetration Failures (D10/A-60U, D11/A-60U) During Class A-60 Test..... | 35 |
| 18. Temperatures on Copper Penetrations (D4/A-60E, D4/A-60U) During Class A-60 Test..... | 36 |
| 19. Temperatures on Copper Penetrations (D10/A-60E, D10/A-60U) During Class A-60 Test..... | 37 |

LIST OF ILLUSTRATIONS (cont'd.)

| | <u>Page</u> |
|---|-------------|
| 20. Temperatures on PVC Penetration Failures (D14/A-60U, D15/A-60U, D16/A-60U) During Class A-60 Test..... | 38 |
| 21. Temperatures on PVC Penetrations (D14/A-60E, D14/A-60U) During Class A-60 Test..... | 39 |
| 22. Temperatures on Ventilation Duct Failures (D17/A-60U, D25/A-60U, D26/A-60U) During Class A-60 Test..... | 41 |
| 23. Temperatures on Ventilation Duct Failures (D17/A-60E, D25/A-60E, D26/A-60E) During Class A-60 Test..... | 42 |
| 24. Temperatures on Electrical Cable Failures (D19/A-60U, D21/A-60U) During Class A-60 Test | 43 |
| 25. Temperatures on Electrical Cable Failures (D22/A-60U, D23/A-60U, D24/A-60U) During Class A-60 Test..... | 44 |
| 26. Temperatures on Electrical Cables Passing the Class A-60 Test..... | 45 |
| 27. Temperatures on Partially Insulated Penetrations..... | 46 |

LIST OF TABLES

| <u>Table</u> | <u>Page</u> |
|--|-------------|
| 1. Number of Samples per Penetration Type..... | 8 |
| 2. Penetration Test Results..... | 17 |
| 3. Penetration Samples Passing a Class A-0 Fire Rating.... | 18 |
| 4. Penetration Samples Passing a Class A-15 Fire Rating... | 19 |
| 5. Penetration Samples Passing a Class A-30 Fire Rating... | 20 |
| 6. Penetration Samples Passing a Class A-60 Fire Rating... | 21 |
| 7. Penetration Samples Passing a Class B-0 Fire Rating.... | 22 |
| 8. Penetration Samples Passing a Class B-15 Fire Rating... | 23 |

1.0 OBJECTIVES

The purpose of the Phase II testing was to identify and test additional penetrations (new and redesigned) to expand the number of alternative designs available to shipbuilders. These penetrations are described in Appendix A. The Phase II work also included modifying and retesting specific penetrations which failed the Phase I testing (Reference 1). A secondary objective was to determine the fire rating classification of each test sample (i.e., Class A-0 through A-60, B-0 and B-15) and to investigate the effects of insulating both the fire and non-fire side of the penetrations. This data will be used in establishing a performance test for individual penetrations submitted for future U. S. Coast Guard approval.

2.0 BACKGROUND

Shipboard fire barrier bulkhead and deck materials may be highly resistant to fire, but if the numerous barrier penetrations necessary for piping, electrical cabling, and ventilation ducting are not equally resistant, barrier integrity can be seriously compromised. To avoid this, details of bulkhead and deck penetrations must be examined to ensure that they do not adversely affect the fire resistance provided by the barrier in which they are installed. Presently, bulkheads and decks aboard merchant vessels are designed to meet fire endurance requirements which are dependent upon their location within the vessel. Once they are installed, they are often breached to allow piping, wiring, or ventilation ducting to pass through. In order to maintain an effective fire boundary, these penetrations must be properly sealed to maintain a degree of fire endurance equivalent to the structural member they pierce.

For example, a penetration through a Class A-60 deck or bulkhead must be capable of: (a) preventing the passage of flame and smoke for one hour, (b) preventing a local temperature rise on the non-fire side of more than 325°F (180°C) above ambient temperature at any one point, and (c) preventing an average temperature rise on the non-fire side of more than 250°F (139°C) above the ambient temperature (Reference 2).

A penetration through a Class B-15 deck or bulkhead, however, must only be capable of: (a) preventing the passage of flame for one-half hour, (b) preventing a local temperature rise on the non-fire side of more than 405°F (225°C) above ambient temperature at any one point, and (c) preventing an average temperature rise on the non-fire side of more than 250°F (139°C) above the ambient temperature (Reference 2).

Criteria found in 46 CFR (Subpart 72.05-10) (Reference 2) establishing fire resistance of bulkheads and decks are based on the widely-recognized ASTM Standard E119 test method (Reference 3). With the E119 method, the test fire barrier panel is incorporated in one face of a furnace. The test furnace is then

fired, and the rate at which the temperature inside the furnace rises is controlled so that the standard time-temperature curve is closely followed. The E119 test measures the fire resistance of the test barrier as determined by the time elapsed before failure (i.e., the passage of flame or smoke, or excessive heat transmission through the barrier). The most important features of E119 is its time-temperature curve. This curve is generally regarded as a more severe exposure than that observed in the typical compartment fire.

Standards which deal with penetrations such as ASTM E814 (Reference 4) and UL 1479 (Reference 5) have appeared only recently. ASTM E814 and UL 1479 are similar in that both incorporate the standard time-temperature curve from ASTM E119 and both allow the same time elapsed before smoke or flame appears on the non-fire side and the same time elapsed before a limiting temperature is exceeded. For the purposes of these tests, UL 1479 may be considered identical to ASTM E814. UL 1479 has been included as Appendix B.

3.0 APPROACH

The Phase I evaluation (Reference 1) used the ASTM E814/UL 1479 test to identify penetration designs which could be used to meet Coast Guard requirements for piercing Class A-0 and Class A-60 decks and bulkheads. Additional tests were needed to identify other practical penetrations and to expand the number of design options available to manufacturers and shipbuilders. This Phase II testing included modifications to earlier penetrations, new designs and also investigated the effect of insulation on the non-fire side of the penetration. In addition, this testing identified the specific fire rating obtained by each penetration instead of just examining two ratings as done in the Phase I testing.

A recognized standard laboratory fire resistance test method using a test furnace with a controlled time-temperature curve was considered essential for ensuring the validity of the tests and for reducing possible variations in the results. In addition, this type of testing with a controlled temperature curve could be reproduced at a later date and the results compared using different test samples. A modified ASTM E814/UL 1479, where the fire stop devices were installed in a steel deck in lieu of a concrete floor, was used as the test method because it complied with these criteria. Although ASTM E814/UL 1479 defines the term through-penetration fire stop as a penetration in a bulkhead or deck which includes fire resistant material, the term penetration will be used in this report for brevity. The term penetrant has been used in this report when referring to the penetration component, such as a tube or sleeve, that actually pierces the boundary structure.

The penetrations tested could have been installed in either a deck or bulkhead. They were tested in what was considered a

worst case scenario, an overhead deck installation in lieu of a bulkhead installation. The types of penetrations investigated were:

- Piping: steel, copper, plastic (PVC) (Figure 1)
- Ventilation ducting: without damper (Figure 2)
- Electrical cabling: multiple, single cables (Figure 3)

Test exposure was designed to determine whether the penetrations met either Class A or Class B (when installed in a steel deck or bulkhead) fire ratings for the passage of flame, smoke and heat transmission. Eight penetrations were not insulated and the other thirty penetrations were insulated with approved structural insulation.

Individual penetrations were selected for testing from the following groups:

Piping penetration details similar to those shown in U.S. Coast Guard Navigation and Vessel Inspection Circular No. 6-80 and Canadian Coast Guard standard sketches (References 6 and 7).

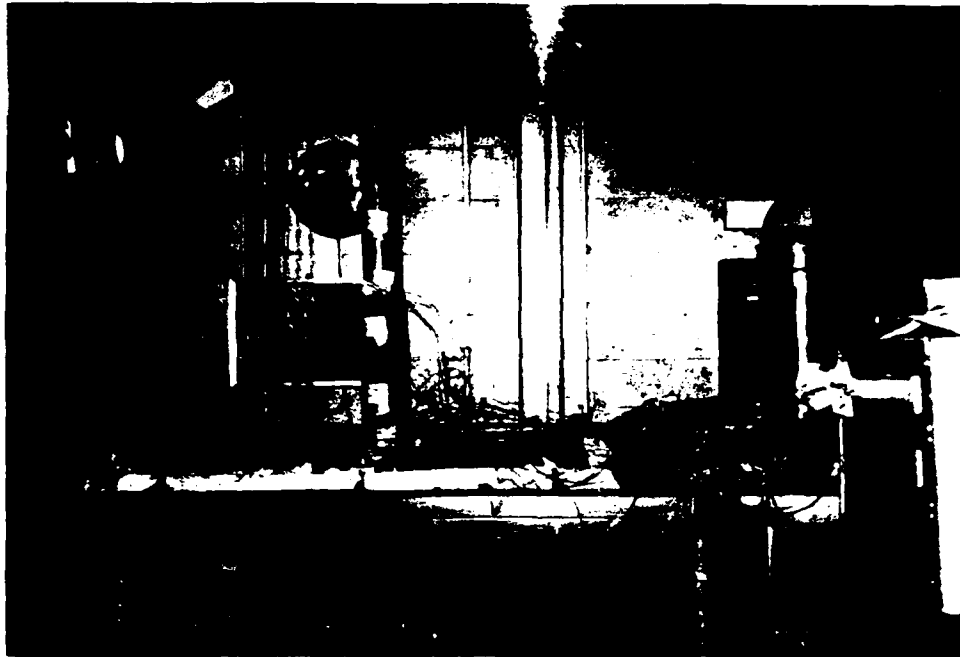
Ventilation duct penetration details similar to designs shown in Canadian Coast Guard standard sketches (Reference 7).

Electrical cable penetration details similar either to designs already approved by the U.S. Coast Guard and listed in CG-293 (Reference 8) or to designs shown in Canadian Coast Guard standard sketches. (Reference 7).

Primary interest was in penetrations for steel, nonferrous, and non-metallic pipe; single and multiple electrical cable runs; and ordinary ventilation ducting. A general description of each penetration tested is included in Appendix A. A detailed drawing and a technical description of each penetration assembly are located in the individual data sections of Appendix C. Deck coverings were not tested, since this would introduce a possible flammability problem for the testing laboratory if the covering or the adhesive on the unexposed surface of the furnace were to ignite. Only one sample of each selected penetration design was tested because of the high price of sample construction, test costs, and the time required to test the many samples selected.

4.0 TEST METHOD

The penetrations were subjected to the modified ASTM E814/UL 1479 tests in order to obtain data as to their acceptability for installation in Class A and Class B divisions. The standard includes provisions for fire exposure, heat transmission, and hose (water) stream tests. The ASTM E814/UL 1479 time-temperature curve was followed for each test and the following data was obtained for each penetration type:



Copper Pipe



Plastic Pipe

FIGURE 1. Piping Penetrations

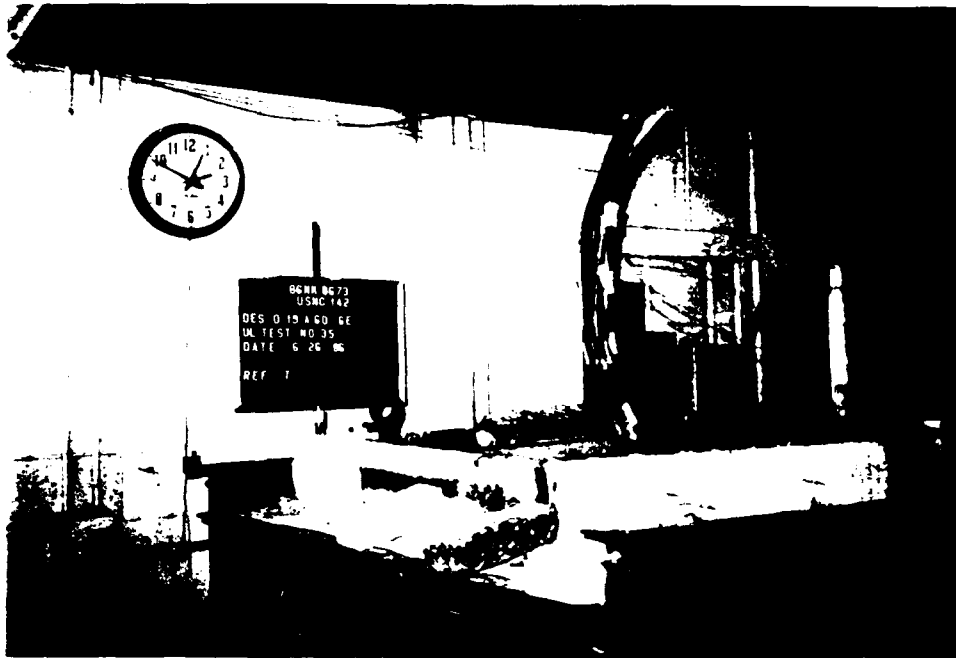


Circular Duct



Square Duct

FIGURE 2. Ventilation Ducting Penetrations



Multiple Cables



Single Cable

FIGURE 3. Electrical Cabling Penetrations

- o The time that flame was observed on the non-fire side.
- o The time that smoke was observed on the non-fire side.
- o The time-temperature history on the non-fire side.
- o Observations of significant details of the behavior of the penetration during the test, and a description of the condition of the penetration after the test.
- o A photographic record of the test arrangement and significant behavior during the test.

Each test was continued for at least 60 minutes unless serious failure occurred earlier. Underwriters Laboratories' one cubic meter furnace was used for all tests because of time and cost considerations of setting up their large furnace for only one sample per test. The smaller furnace was also more practical and less expensive for compliance testing of a limited number of samples being tested at one time. UL verified that the results of tests conducted in their one cubic meter furnace were comparable to results produced in their larger furnaces.

5.0 PROCEDURES

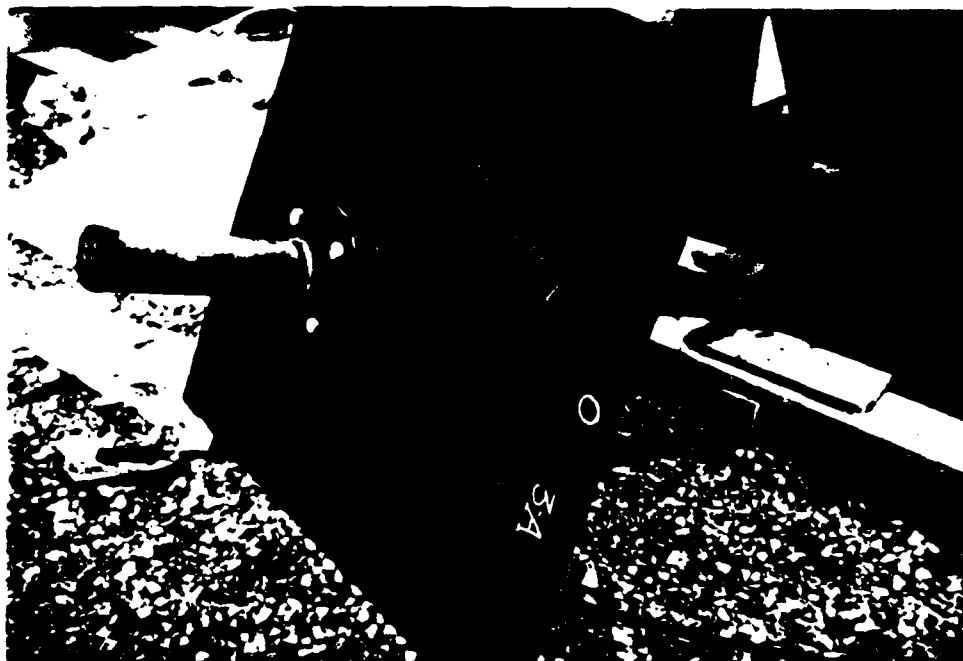
This research testing was intended to identify various through-penetration fire stops that meet either Class A or B criteria using the modified ASTM E814/UL 1479 fire test procedures as a general guide. However, the testing was not intended as a validation of either ASTM E814 or UL 1479. Therefore, certain aspects of the testing procedures were modified to obtain more extensive test data. This permitted investigating different insulation placement, thermocouple location and penetrations of various construction designs and materials for marine use.

Eighteen penetration types were evaluated in thirty-eight fire tests. Table 1 shows the number of penetrations tested of each type. One steel piping type was evaluated in one test. Six copper piping types were evaluated in nine tests. Three PVC piping types were evaluated in five tests. Three ventilation duct types were evaluated in nine tests. Five electrical penetration types were evaluated in fourteen tests.

Each penetration was installed in a class A-0 deck assembly (Figure 4). Eight penetrations were tested for a Class A-0 rating and thirty penetrations were insulated with approved structural insulation and tested for a Class A-60 rating. Nine penetrations were insulated on the fire side (Figure 5) and were designated Class A-60E to indicate the insulation was on the side of the penetrant exposed to the fire. Eighteen penetrations were insulated on the non-fire side (Figure 6) and were designated Class A-60U to indicate the insulation was located on the

TABLE 1
NUMBER OF SAMPLES PER PENETRATION TYPE

| Description of Penetration Types | Class A-0 Samples No Insulation Sample No. | Class A-60E Samples Insulation on Exposed (E) Fire Side Sample No. | Class A-60U Samples Insulation on Unexposed (U) Fire Side Sample No. | Partially Insulated Steel Plate Sample No. |
|---|--|---|---|--|
| Steel Pipe | | | D3/A-60U | |
| Copper Pipe | | D4/A-60E | D4/A-60U | |
| Copper Pipe | | | D5/A-60U | |
| Copper Pipe | | | D6/A-60U | |
| Copper Pipe | | | D9/A-60U | |
| Copper Pipe | D10/A-0 | D10/A-60E | D10/A-60U | |
| Copper Pipe | | | D11/A-60U | |
| PVC Pipe | D14/A-0 | D14/A-60E | D14/A-60U | |
| PVC Pipe | | | D15/A-60U | |
| PVC Pipe | | | D16/A-60U | |
| Vent Duct | D17/A-0 | D17/A-60E | D17/A-60U | |
| Multiple Elect. Cable | | | D19/A-60U | D19/A-60-6E D19/A-60-6U D19/A-60-3E&3U |
| Single Elect. Cable | | | D21/A-60U | |
| Single Elect. Cable | D22/A-0 | D22/A-60E | D22/A-60U | |
| Single Elect. Cable | D23/A-0 | D23/A-60E | D23/A-60U | |
| Single Elect. Cable | D24/A-0 | D24/A-60E | D24/A-60U | |
| Vent Duct | D25/A-0 | D25/A-60E | D25/A-60U | |
| Vent Duct | D26/A-0 | D26/A-60E | D26/A-60U | |



Copper Pipe



Ventilation Duct

FIGURE 4. Class A-0 Construction



Circular Ventilation Ducting

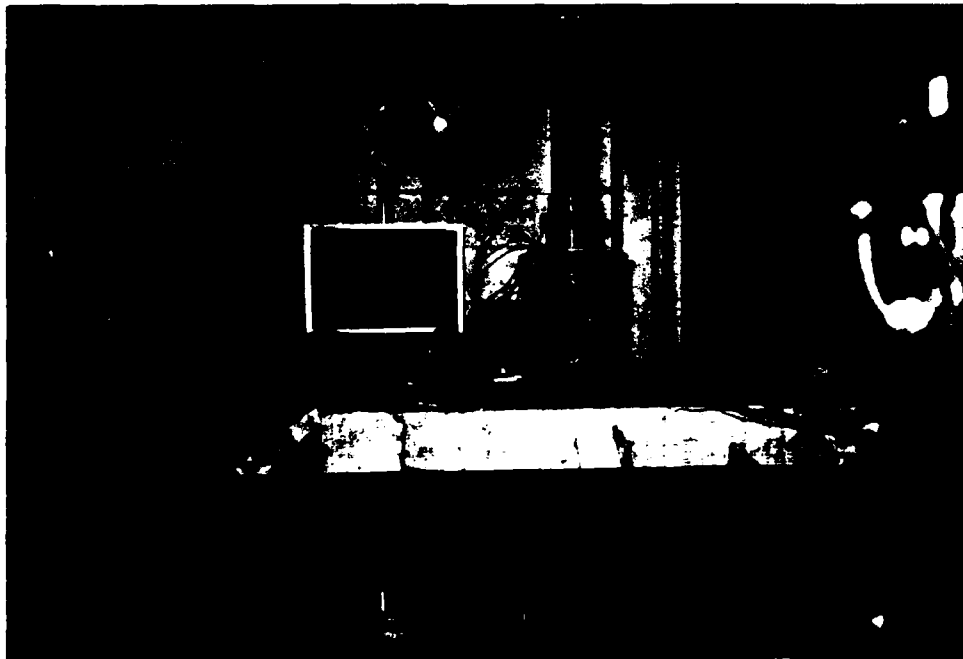


Single Electric Cable

FIGURE 5 Class A-60 Construction Insulated on Fire Side



Electric Cable



Plastic Piping

FIGURE 6. Class A-60 Construction Insulated on Non-fire Side

unexposed (non-fire) side of the penetrant. Three penetrations were insulated in a six-inch (15.2 cm) square around the penetrant on the steel plate to determine the effect produced by the hot plate being close to the penetrant. In this situation, the penetrant actually acts as a heat sink. A number was given before the E or U (e.g., A-60-6U) to indicate the depth or height in inches of insulation on the penetrant.

Nine to twenty-eight temperature readings were recorded inside the furnace and on the non-fire side of the penetrant and deck assemblies for each test. The total number of thermocouples exceeded that required for ASTM E814/UL 1479 in order to better characterize temperatures occurring on the penetrant and on the steel plate. For example, ASTM E814/UL 1479 required only one thermocouple on the penetrant whereas five or more thermocouples were placed on the penetrant for this testing. These thermocouples were generally placed at heights of 4, 6, 12, 18, and 24 inches (10.2, 15.2, 30.5, 45.7, and 61.0 cm) up the penetrant's non-fire side. Although ASTM E814/UL 1479 required only three thermocouples on the steel plate an equal distance from the penetrant, five thermocouples were used in this testing to better characterize the temperature on the non-fire side of the penetrant. Generally, one thermocouple was placed on the steel plate one inch (2.5 cm) from the penetrant, two thermocouples were placed 3 to 6 inches (7.6 to 15.2 cm) from the penetrant and two more were placed 8 to 12 inches (20.3 to 30.5 cm) from the penetrant. An effort was made to duplicate the location of the thermocouples for each test but the size, shape and construction of each penetrant often made this impossible. Some thermocouples on the deck assembly insulation were positioned over the seam produced when two sections of insulation were joined. Readings from the thermocouples positioned on the partially insulated steel plates which were outside the locations required for normal fire rating classifications were ignored.

Observations and measurements were made for the development of breaches or flaming on the unexposed surface, acceptable limits of temperature rise and the passage of water during the hose stream test. Pressures within the furnace and of the water stream were also recorded. A 35 mm camera was used to provide a photographic record of the tests. Videotape recordings were made of each test and of the overall test procedures. Test data, as recorded by UL, is included in Appendix C.

5.1 Test Assembly Construction

The U.S. Coast Guard and the Canadian Coast Guard selected and designed the penetration samples and firestop systems. The penetrations consisted of standard construction materials and represented standard firestop systems. The samples were manufactured by Davie Shipbuilding Limited in Quebec, Canada and were delivered to Underwriters Laboratories in Chicago, Illinois. Each penetration type was in a 36-inch x 36-inch x 3/16-inch (91.4 cm x 91.4 cm x 0.5 cm) thick steel plate. All sample

construction was representative of Class A-0 construction. The UL staff secured insulation (rockwool batts) to the designated side of the steel plates and penetrants for testing as Class A-60 deck assemblies. The rockwool batts complied with the Class A-60 structural insulation requirements of 46 CFR 164.007 (Reference 9). The attachment of the batts to the penetrations and assemblies is described in Appendix C. A fire resistant sealant (RTV silicone rubber with a one hour fire rating) was used to seal the joint area in different penetration samples. A caulking gun was used to compress the sealant to a 2 to 4-inch (5.1 to 10.2 cm) depth between the different piping joints.

5.2 Fire Exposure Test

The penetration assemblies were tested in accordance with the requirements of ASTM E814/UL 1479. The tests were conducted in the horizontal furnace shown in Figure 7. The furnace has a 31.5-inch x 31.5-inch (80 cm x 80 cm) opening. A detail drawing of the furnace is presented in Appendix C. Furnace temperatures were regulated to follow the standard time-temperature curve in ASTM E814/UL 1479. Type K chromel alumel thermocouples were used for all temperature measurements. The thermocouple locations for each sample are listed in Appendix C.

The standard time-temperature curve in ASTM E814/UL 1479 was followed for each fire test. Figure 8 shows the standard time-temperature curve and actual curves recorded inside the furnace for three penetration tests. The temperatures for the other penetration tests are similar to these three curves. A comparison of the area under the test curves with the area under the standard time-temperature curve indicates a deviation of no greater than +/- 1 percent for each 60-minute test. This is well within the Coast Guard acceptable deviation limits (Reference 9).

Prior to fire testing, the penetration samples were stored for two days inside the room containing the test furnace. The room lacked air conditioning and was located on the third level of a four story building. All testing took place in mid-summer. In order to expedite the testing, two samples were tested in the furnace each day. As a result, the furnace temperature at the start of the second test of the day was slightly above normal ambient conditions, since 12 hours would have been needed for the furnace to cool down to room temperature. These test conditions produced an ambient room temperature above 90°F (32.2°C) with an atmosphere of less than 50 percent relative humidity.

Observations were recorded during the testing in order to determine the passage of smoke or flame through any penetration sample. It should be noted that if smoke from inside the furnace passes around the edges of the sample's steel mounting plate, this does not constitute a smoke failure, since the smoke does not pass through the penetrant itself.



Furnace Controls



Sample Being Removed from Furnace

FIGURE 7. U.L. Test Furnace

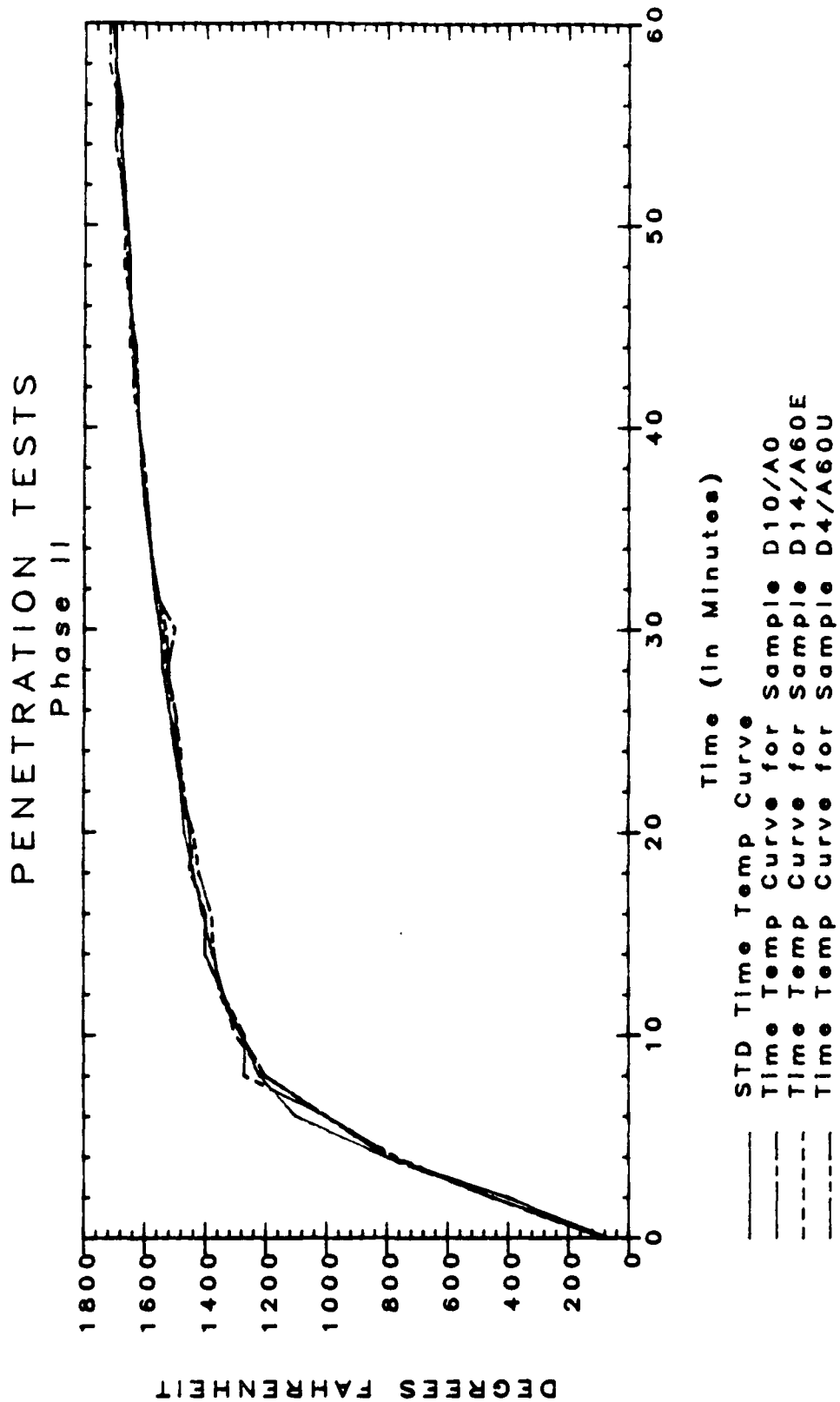


FIGURE 8. Standard Time-Temperature Curve versus Penetration Time-Temperature Curves

An electronic barometer was used during the fire tests to measure the pressure differential between the furnace and the laboratory. The differential pressure normally employed in testing is that pressure which the penetration will experience in actual operation. For our test purposes, the pressure differential was that created by operating the furnace so as to follow the standard time-temperature curve. This pressure differential was measured and recorded for six tests. The furnace operation for these six tests was identical to the furnace operation for all remaining tests. The pressure differential was 0.005 mm Hg (0.7 Pa) negative at the beginning of each test, but gradually increased to a maximum positive pressure differential of 0.01 mm Hg (1.33 Pa) by the end of each 60-minute test. Observations of the test results were recorded for each penetration sample in Appendix C.

5.3 Hose Stream Test

As required by ASTM E814/UL 1479, a hose stream test was conducted on the penetration samples immediately following the 1-hour fire test. The sample was removed from the furnace, placed in a steel support rack and pivoted vertically 90 degrees to represent a wall assembly. Approximately four minutes after the furnace fire was extinguished, a 30-psi water stream was applied from a perpendicular distance of 20 feet (6.1 m) from the center of the test assembly. The water stream was applied to the deck assembly and penetrating item for 13.5 seconds.

6.0 RESULTS AND DISCUSSION

The number of samples tested for each of the penetration types is shown in Table 1. Penetration test results are summarized in Table 2. This table indicates the time that flame or smoke appeared, and/or a temperature rise of 325°F (180°C) above ambient occurred on the unexposed side of the sample. It also indicates the results of the hose stream test. These test results are categorically separated in Tables 3 through 8 to show the specific classification that each penetration sample achieved, such as Class A-0, A-15, A-30, A-60, as well as B-0 and B-15 for devices installed in steel decks or bulkheads. A discussion of the test results appears in sections 6.1 and 6.2. In the discussions, "spigot" refers to a length of pipe which either replaces or encloses a continuous run of pipe, duct, or electrical cable.

6.1 Class A-0 Penetrations

Eight penetrations (one copper penetration, one PVC penetration, three ventilation duct penetrations and three electrical cable penetrations) were tested for a Class A-0 rating. Two penetration samples, D22/A-0 and D24/A-0, failed the Class A-0 exposure tests (Figure 9). At eighteen minutes into the test the single electrical cable penetration D22/A-0 began to issue smoke at the interface of the cable and the brass terminal tube. At forty-two minutes the cable was still issuing

TABLE 2

[illegible]

TABLE 3
PENETRATION SAMPLES PASSING A CLASS A-0 FIRE RATING

| Class A-0 Samples No Insulation | | | | Class A-60U Samples Insulation on Unexposed (U) Fire Side | | | |
|---|---------------|-----------------|-----------------|---|---------------|-----------------|-----------------|
| Description of Penetration Types | Sample No. | Flame (min.) | Smoke (min.) | Description of Penetration Types | Sample No. | Flame (min.) | Smoke (min.) |
| Copper Pipe | D10/A-0 | >60 | >60 | Steel Pipe | D3/A60U | >60 | >60 |
| PVC Pipe | D14/A-0 | >60 | >60 | | | | |
| Vent Duct | D17/A-0 | >60 | >60 | | | | |
| Single | | | | | | | |
| Elect. Cable | D23/A-0 | >60 | >60 | | | | |
| Vent Duct | D25/A-0 | >60 | >60 | | | | |
| Vent Duct | D26/A-0 | >60 | >60 | | | | |

TABLE 4
PENETRATION SAMPLES PASSING A CLASS A-15 FIRE RATING

| ----- Class A-60U Samples Insulation on Unexposed (U) Fire Side ----- | | | | |
|--|---------------|-----------------|-----------------|---|
| Description of Penetration Types | Sample No. | Flame (min.) | Smoke (min.) | Temp. Rise of 325 deg.F (180 deg.C) (min.) |
| Copper Pipe | D4/A-60U | >60 | >60 | 24 |
| Copper Pipe | D5/A-60U | >60 | >60 | 28 |
| Copper Pipe | D6/A-60U | >60 | >60 | 26 |
| Copper Pipe | D9/A-60U | >60 | >60 | 18 |
| Copper Pipe | D10/A-60U | >60 | >60 | 24 |
| Copper Pipe | D11/A-60U | >60 | >60 | 26 |
| PVC Pipe | D15/A-60U | >60 | >60 | 22 |
| PVC Pipe | D16/A-60U | >60 | >60 | 29 |
| Vent Duct | D17/A-60U | >60 | >60 | 29 |
| Multiple | | | | |
| Elect. Cable | D19/A-60U | >60 | >60 | 22 |
| Single | | | | |
| Elect. Cable | D21/A-60U | >60 | >60 | 27 |
| Single | | | | |
| Elect. Cable | D22/A-60U | >60 | >60 | 23 |
| Single | | | | |
| Elect. Cable | D23/A-60U | >60 | >60 | 27 |
| Vent Duct | D25/A-60U | >60 | >60 | 18 |
| Vent Duct | D26/A-60U | >60 | >60 | 16 |
| ----- | | | | |

TABLE 5
PENETRATION SAMPLES PASSING A CLASS A-30 FIRE RATING

| Class A-60E Samples Insulation on Exposed (E) Fire Side | | | | | Class A-60U Samples Insulation on Unexposed (U) Fire Side | | | | |
|---|---------------|-----------------|-----------------|---|---|---------------|-----------------|-----------------|---|
| Description of Penetration Types | Sample No. | Flame (min.) | Smoke (min.) | Temp. Rise of 325 deg.F (180 deg.C) (min.) | Description of Penetration Types | Sample No. | Flame (min.) | Smoke (min.) | Temp. Rise of 325 deg.F (180 deg.C) (min.) |
| Vent Duct | D17/A-60E | >60 | >60 | 48 | PVC Pipe | D14/A-60U | >60 | >60 | 36 |
| Vent Duct | D26/A-60E | >60 | >60 | 44 | | | | | |
| Vent Duct | D25/A-60E | >60 | >60 | 36 | | | | | |

TABLE 6
PENETRATION SAMPLES PASSING A CLASS A-60 FIRE RATING

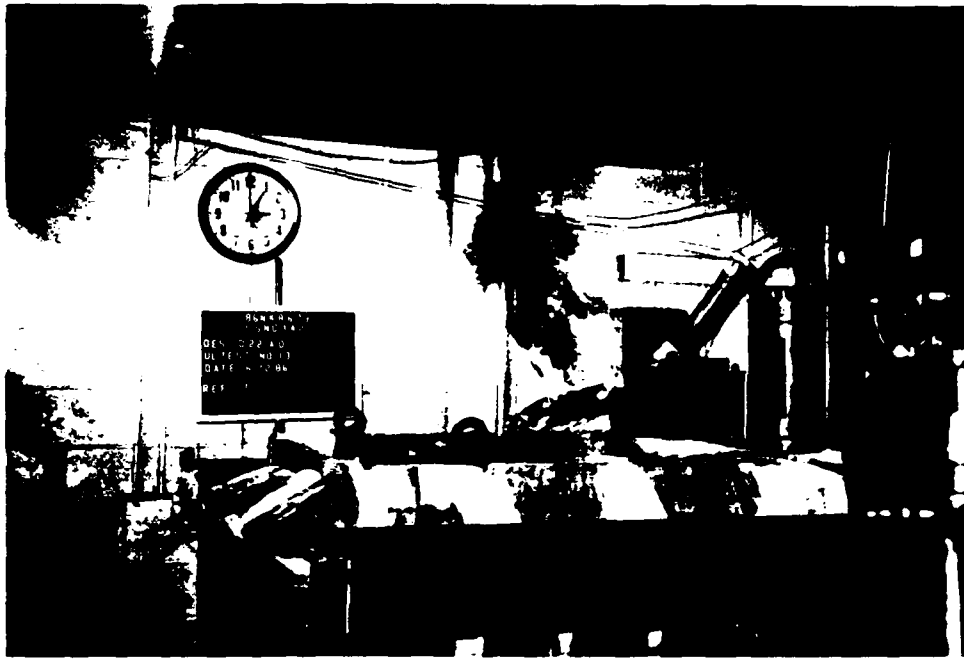
| ----- Class A-60E Samples Insulation on Exposed (E) Fire Side ----- | | | | |
|--|---------------|-----------------|-----------------|---|
| Description of Penetration Types | Sample No. | Flame (min.) | Smoke (min.) | Temp. Rise of 325 deg.F (180 deg.C) (min.) |
| Copper Pipe | D4/A-60E | >60 | >60 | >60 |
| Copper Pipe | D10/A-60E | >60 | >60 | >60 |
| PVC Pipe | D14/A-60E | >60 | >60 | >60 |
| Single Elect. Cable | D22/A-60E | >60 | >60 | >60 |
| ----- | | | | |

TABLE 7
PENETRATION SAMPLES PASSING A CLASS B-0 FIRE RATING
(as installed in a steel deck or bulkhead)

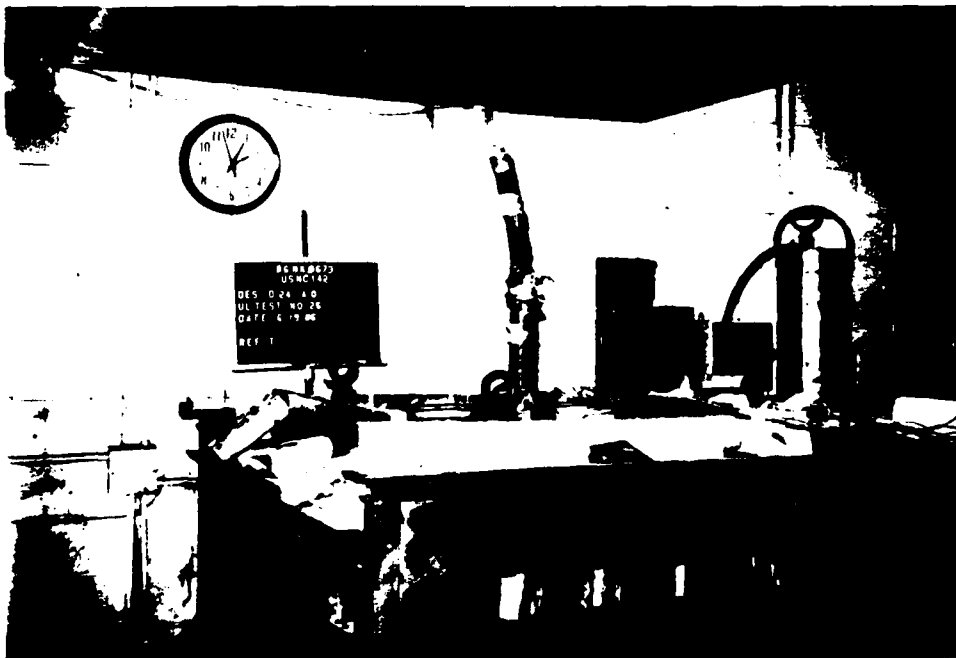
| ----- Class A-0 Samples No Insulation ----- | | | |
|--|---------------|-----------------|---|
| Description of Penetration Types | Sample No. | Flame (min.) | Temp. Rise of 405 deg.F (225 deg.C) (min.) |
| ----- | | | |
| Single Elect. Cable | D22/A-0 | 59 | 4 |
| Single Elect. Cable | D24/A-0 | >60 | 14 |
| ----- | | | |

TABLE 8
PENETRATION SAMPLES PASSING A CLASS B-15 FIRE RATING
(as installed in a steel deck or bulkhead)

| Class A-60E Samples Insulation on Exposed (E) Fire Side | | | | Class A-60U Samples Insulation on Unexposed (U) Fire Side | | | | Partially Insulated Steel Plate | | | |
|---|---------------|-----------------|---|---|---------------|-----------------|---|---|----------------|-----------------|---|
| Description of Penetration Types | Sample No. | Flame (min.) | Temp. Rise of 405 deg.F (225 deg.C) (min.) | Description of Penetration Types | Sample No. | Flame (min.) | Temp. Rise of 405 deg.F (225 deg.C) (min.) | Description of Penetration Types | Sample No. | Flame (min.) | Temp. Rise of 405 deg.F (225 deg.C) (min.) |
| Single Elect. Cable | D23/A-60E | >60 | >60 | Single Elect. Cable | D24/A-60U | >60 | 42 | Multiple Elect. Cable | D19/A-60-6E | >60 | 20 |
| Single Elect. Cable | D24/A-60E | >60 | >60 | | | | | Multiple Elect. Cable | D19/A-60-6U | >60 | 32 |
| | | | | | | | | Multiple Elect. Cable | D19/A-60-3E&3U | 55 | 51 |



D22/A-O (Single Electrical Cable)



D24/A-O (Single Electrical Cable)

FIGURE 9. Class A-O Test Failures

smoke and was heavily charred. The cable jacket burst into flames at fifty-nine minutes. At the conclusion of the one hour fire test, a hose stream test was conducted. The single electrical cable penetration D24/A-0 began to issue smoke from the interface of the cable and the steel pipe at six minutes into the test. At forty minutes, the smoke intensity increased and the cable began to deteriorate badly. The hose stream test was conducted since the electrical cable did not collapse into the furnace.

The test data in Appendix C indicate the presence of smoke on the non-fire side of the Class A-0 penetrations D10/A-0, D14/A-0, D22/A-0, D23/A-0, and D24/A-0. A review of the photographic documentation indicates that only penetrations D22/A-0 and D24/A-0 appeared to pass smoke through the penetrant. Based on interpretation of photographic evidence, the occurrence of smoke on the non-fire side of penetrations D10/A-0, D14/A-0 and D23/A-0 was determined to be the result of moisture being driven from the sample, contaminant oils smoldering on the penetrant's non-fire side, off-gassing of the fiberglass used to seal the steel plate to the furnace top, and smoke coming from under the steel plate assembly where it was not sealed securely to the top of the furnace. It appeared that no smoke actually passed through the penetrants in any of these three tests.

The copper penetration D10/A-0 passed the Class A-0 fire exposure test. Figure 10 shows three temperature plots for different heights on the steel spigot enclosing the copper pipe and one temperature plot for the copper pipe one inch (2.5 cm) above the steel spigot. This figure shows that after fifteen minutes into the test the copper pipe at a one-inch (2.5 cm) height above the spigot remained over 125°F (69.4°C) hotter than the spigot throughout the test.

The PVC penetration threaded to a steel spigot (D14/A-0) passed the Class A-0 fire exposure test. Observations recorded in the Appendix C data sheet for this sample indicated the presence of smoke on its non-fire side, but a review of the photographic documentation clearly indicated that the smoke did not come through the penetrant, but rather from around the edges of the steel plate assembly where it lay on top of the furnace. It is interesting to note that the temperatures (Figure 10) recorded at the 12-inch (30.5 cm) height on the PVC penetrant (D14/A-0) and the copper penetrant (D10/A-0) were similar, while temperatures recorded at the 4-inch (10.2 cm) height were over 160°F (71.1°C) higher on the PVC penetrant. Both these penetrations had a steel spigot on which these temperatures were measured. The interesting point is that the steel spigot threaded to a PVC pipe was the hottest at a 12-inch (30.5 cm) height, while a steel spigot with a copper pipe through it was cooler at this same height. It appears that the copper pipe inside the steel spigot acts as a heat sink as the distance increases from the steel plate.

SAMPLE D10/A0

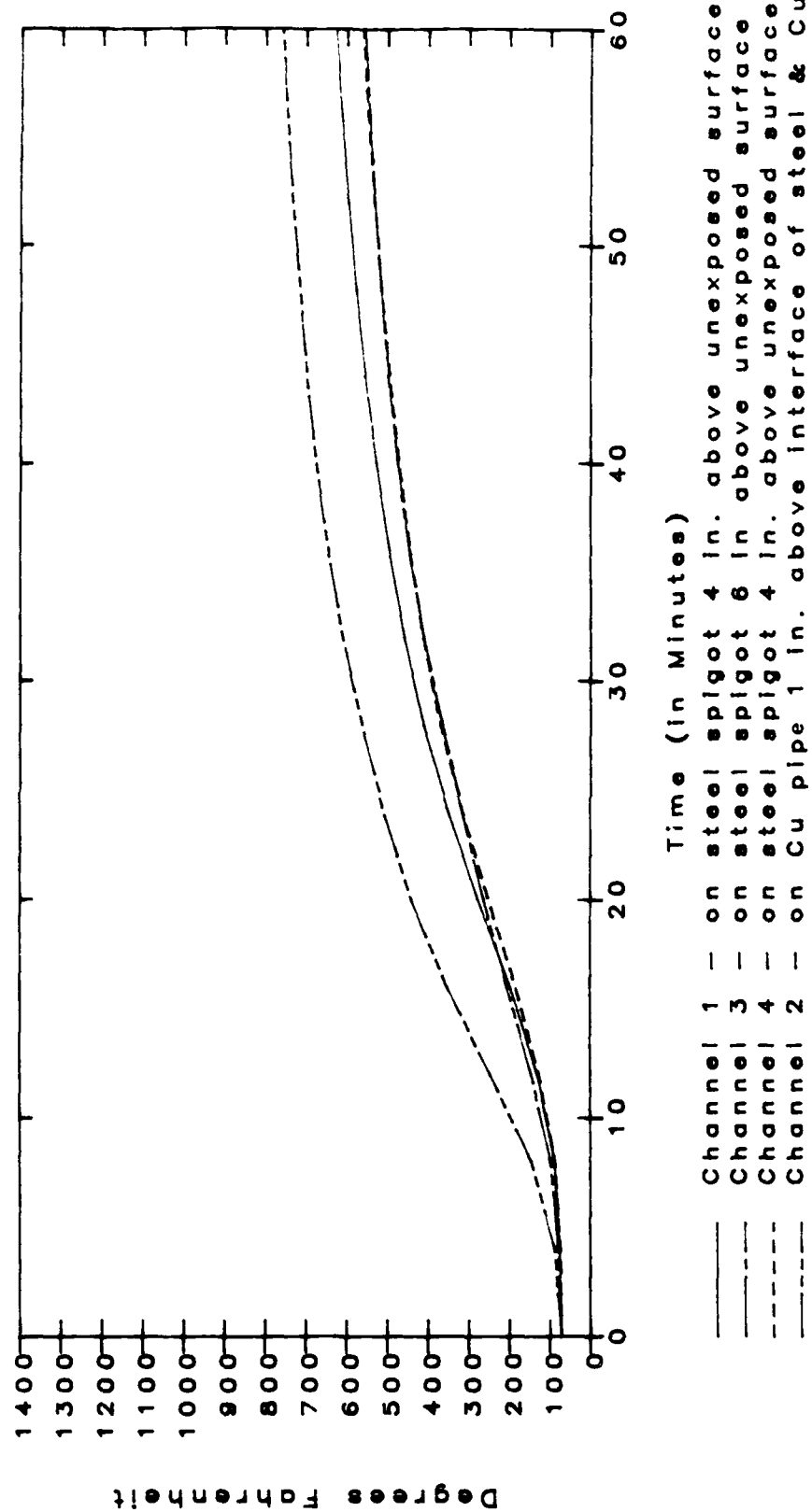


FIGURE 10. Temperatures on Copper Penetrant (D10/A-O) During Class A-O Test

It is also interesting to note that the temperatures at a 12-inch (30.5 cm) height on a steel spigot threaded to a PVC penetrant (D4/A-0) and on a steel spigot with a continuous copper pipe through it were similar (Figure 11), whereas temperatures recorded at a 4-inch (10.2 cm) height on both steel spigots were over 160°F (88.9°C) hotter on the spigot with the PVC pipe. It appears that the copper pipe inside the steel spigot acts as a heat sink as the distance increases from the steel plate.

Three ventilation duct penetration types (D17/A-0, D25/A-0, and D/26A-0) were tested for a Class A-0 rating. Each penetration passed the fire exposure test. Each penetrant had a 6-inch (15.2 cm) steel spigot on the fire side and a 30-inch (76.2 cm) steel spigot on the non-fire side. Figure 12 shows temperature plots at a 4-inch (10.2 cm), 12-inch (30.5 cm), and 24-inch (61.0 cm) height on the three penetrants. The temperature plots are similar at the same heights for the three penetrants. A comparison of the temperature plots in Figure 11 and Figure 12 show that temperatures at the 4-inch (10.2 cm) and 12-inch (30.5 cm) height on the ventilation duct penetrants are at least 150°F (83.3°C) hotter than similar heights on the PVC penetrant and the copper penetrant.

Three single electrical cable penetrations (D22/A-0, D23/A-0, and D24/A-0) were tested for a Class A-0 rating. The brass terminal tube used in each of these penetrations was missing an o-ring fitting. Fire retardant oakum was substituted for the missing o-ring. Only sample D23/A-0 passed the Class A-0 test. Figure 13 shows that the three electrical cable penetrations had similar temperature readings at the 4-inch (10.2 cm) height above the steel plate but the penetrant which passed the Class A-0 test reached a temperature of 369°F (187.2°C) after 60 minutes at the 16-inch (40.6 cm) height, compared to temperatures of over 600°F (315.6°C) after 60 minutes at similar heights on the two penetrants which failed the Class A-0 test.

6.2 Class A-60 Penetrations

Thirty penetrations were insulated with rockwool batts and tested for a Class A-60 rating. This group consisted of one steel penetration, eight copper penetrations, four PVC penetrations, six ventilation duct penetrations, and eleven electrical cable penetrations.

Results in Table 1 show that all eighteen penetrations insulated on the non-fire side failed to meet the temperature rise requirements for a Class A-60 rating, while only three of the nine penetrations insulated on the fire side failed to meet those requirements temperature rise test for a Class A-60 rating. The three penetrations with partially insulated steel plates also failed to meet the temperature rise requirements for a Class A-60 rating.

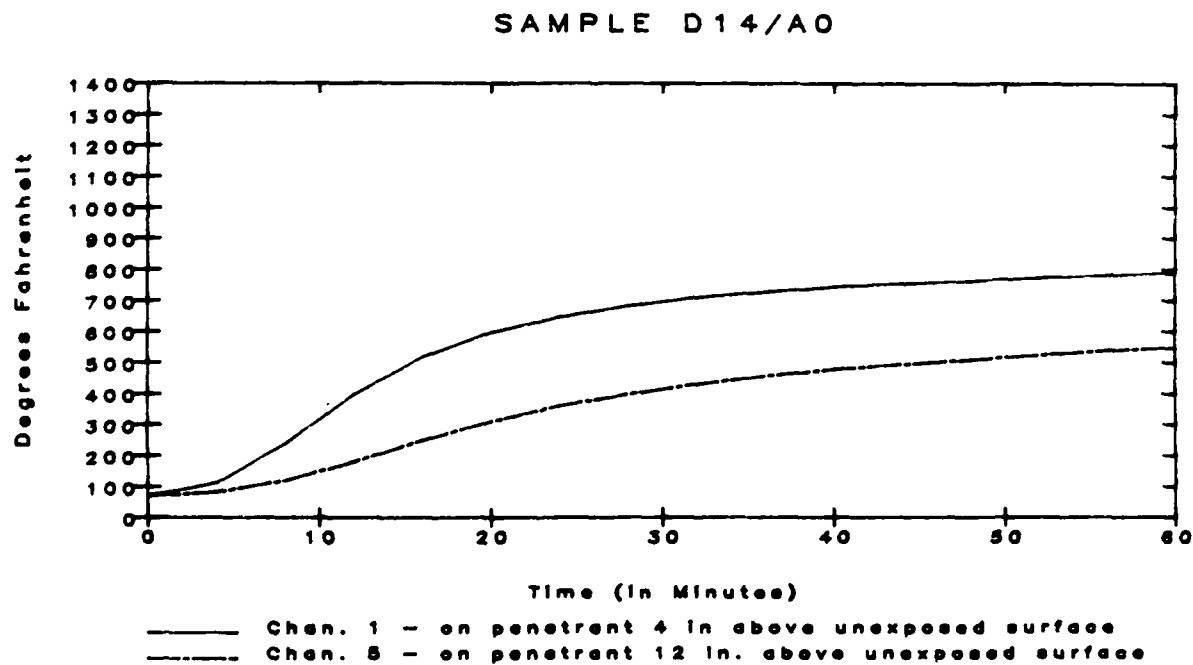
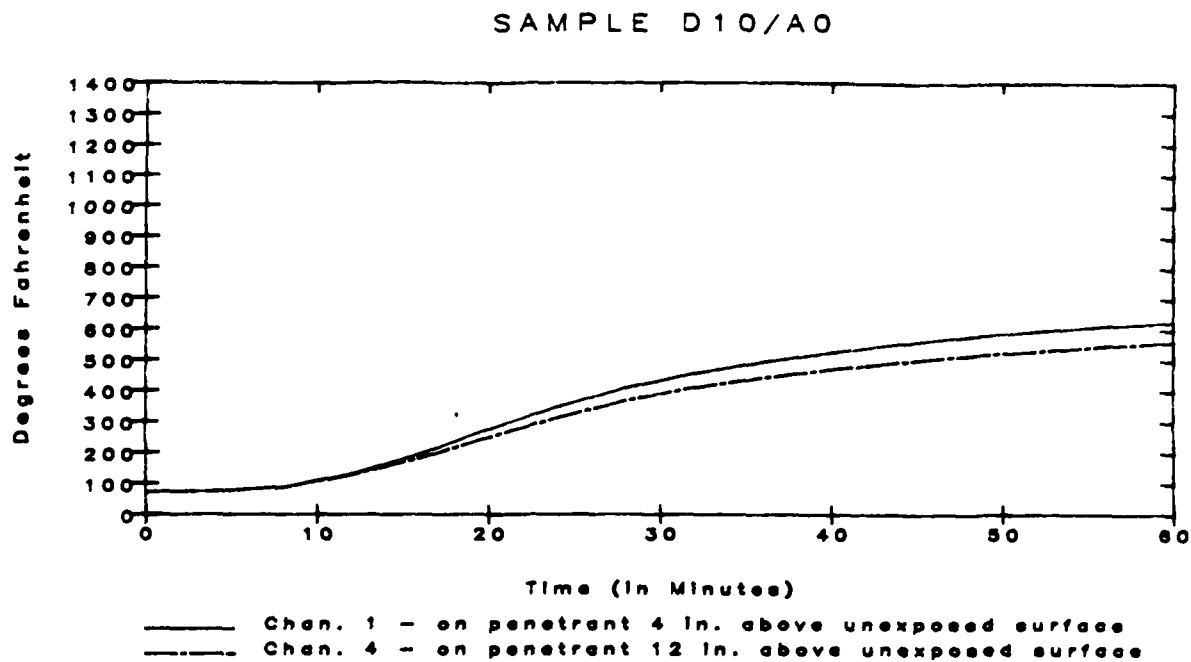


FIGURE 11. Temperatures on PVC Penetrant (D14/A-O) and Copper Penetrant (D10/A-O) During Class A-O Test

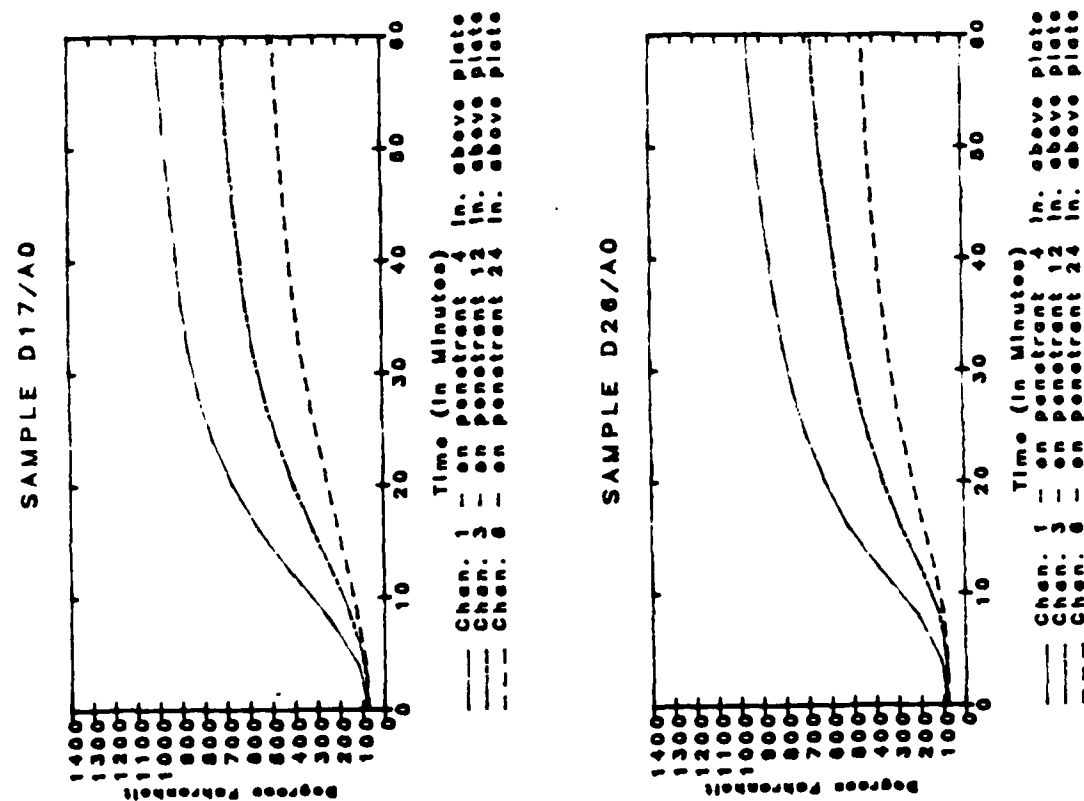


FIGURE 12. Temperatures on Ventilation Ducts (D17/A-O, D25/A-O, D26/A-O) During Class A-O Tests

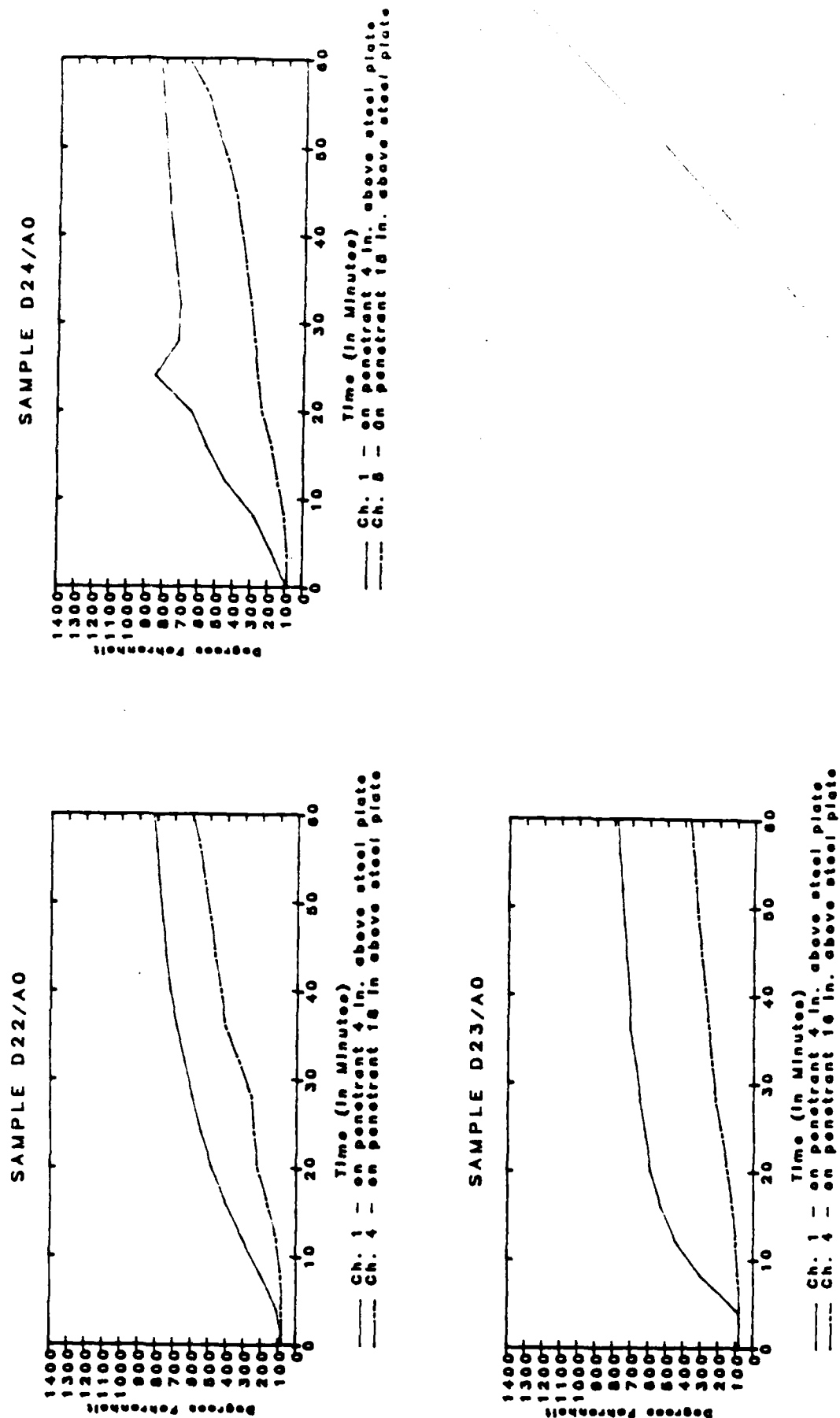


FIGURE 13. Temperatures on Electrical Cable Penetrations (D22/A-O, D23/A-O, D24/A-O) During Class A-O Test

One steel penetration was insulated on the non-fire side and tested. It passed the fire exposure test and hose stream test, but failed to meet the temperature rise requirement. The temperature plots in Figure 14 show the heat transmission at different locations on top of the plate insulation. Two of the temperature plots shown in Figure 14 were recorded at the interface of the steel plate insulation and the penetrant insulation, while the other two temperature plots were recorded on the plate insulation 1-inch (2.5 cm) away from the penetrant insulation. This figure shows that the temperatures over the seams in the insulation at the two separate locations are over 350°F (194.4°C) hotter than temperatures recorded at similar locations but not over a seam. A seam occurred where two pieces of insulation were joined together. Each seam was tightly fitted, but small gaps could occur in the joints quite easily as the rough edges of the insulation were pushed together or as the samples were moved for testing.

Eight copper penetrations were insulated and tested. Two penetrations were insulated on the fire side and passed the requirements for a Class A-60 rating. Six penetrations were insulated on the non-fire side and failed the heat transmission test for a Class A-60 rating. Figures 15, 16, and 17 show temperatures above the acceptable temperature rise limits for the six penetrations which failed. These failure temperatures occurred on both the penetrant insulation and on the steel plate insulation for the six penetrations. Figure 18 shows the temperature plots for two copper penetrations which are identical in construction except that one sample is insulated on the fire side and the other sample is insulated on the non-fire side. Figure 19 shows the same arrangement for another pair of identical copper penetrations. In these two figures, the temperature plots show that the penetrations insulated on the non-fire side failed to meet the temperature rise requirement, while temperature plots at identical locations on the penetrations insulated on the fire side show these penetrations met this requirement. This points out the value of insulating the fire side to provide a greater degree of protection against temperature rise.

Four PVC penetrations were tested for a Class A-60 rating. Three of the penetrations were insulated on the non-fire side and failed the temperature rise requirement for a Class A-60 rating. The temperature plots in Figure 20 show that the temperature limits were exceeded for these three penetrations on both the penetrant insulation and the steel plate insulation. One penetration was insulated on the fire side and passed the test requirements for a Class A-60 rating. Figure 21 shows the temperature plots for two PVC penetrations which are identical in construction except that one sample is insulated on the fire side and the other sample is insulated on the non-fire side. The temperature plots show that the penetration insulated on the fire side passed the temperature requirement while the sample insulated on the non-fire side failed. Again, this indicates

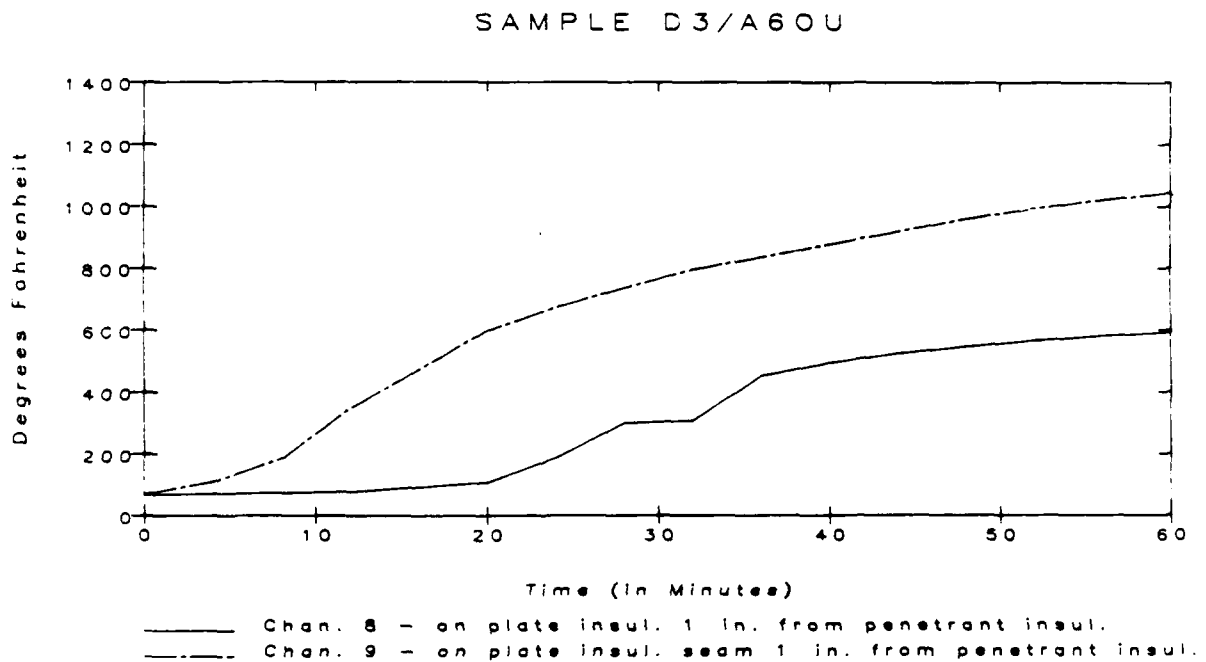
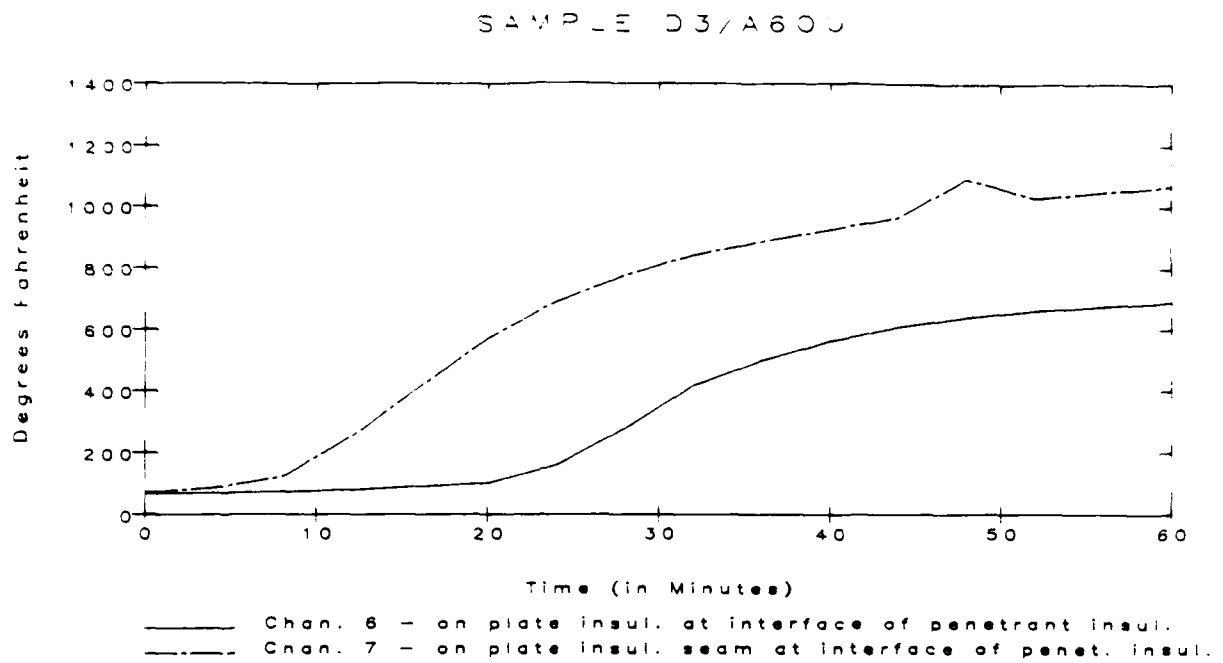
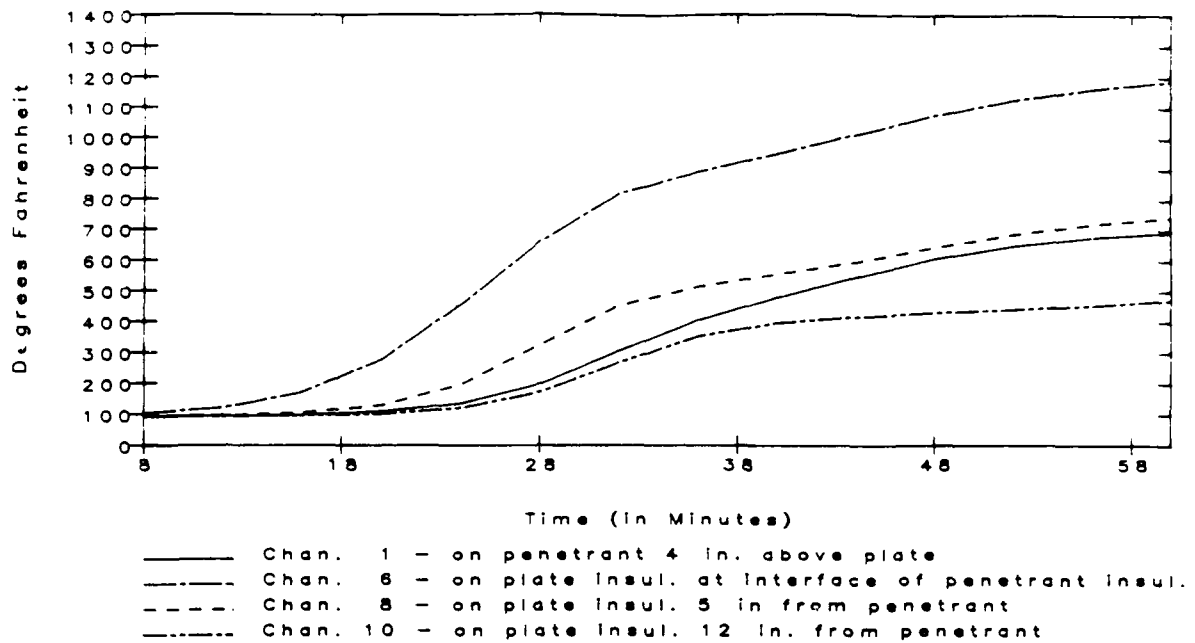


FIGURE 14. Temperatures on Steel Penetration Failure (D3/A-60U) During Class A-60 Test

SAMPLE D4/A60U



SAMPLE D5/A60U

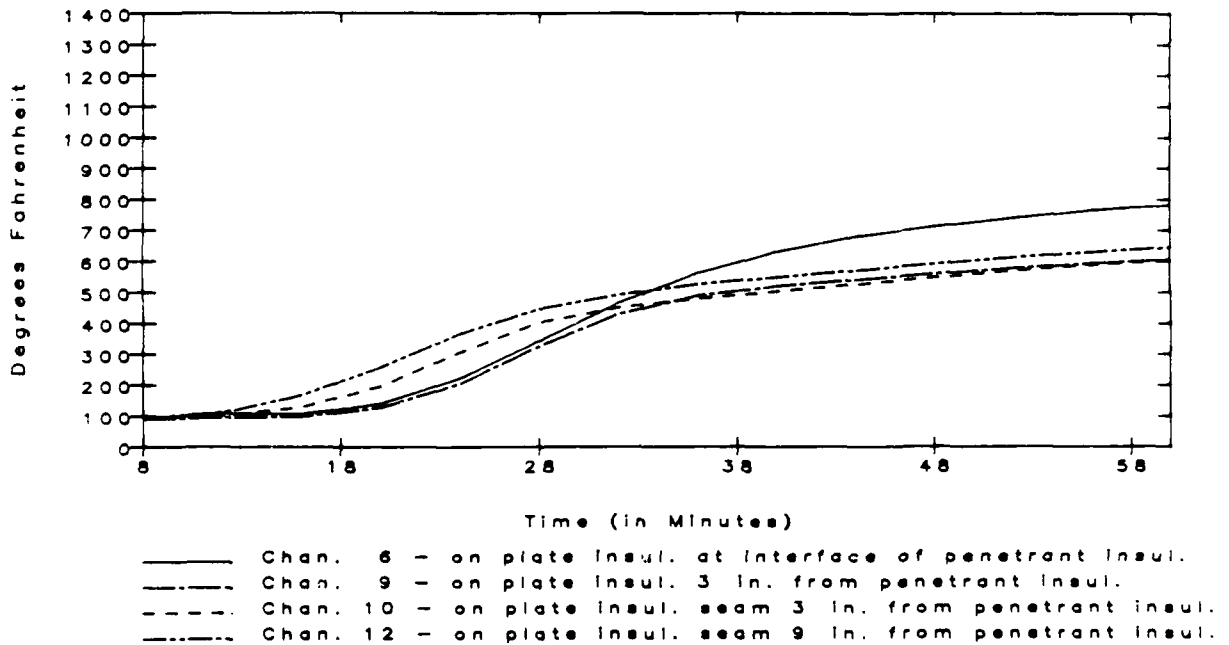
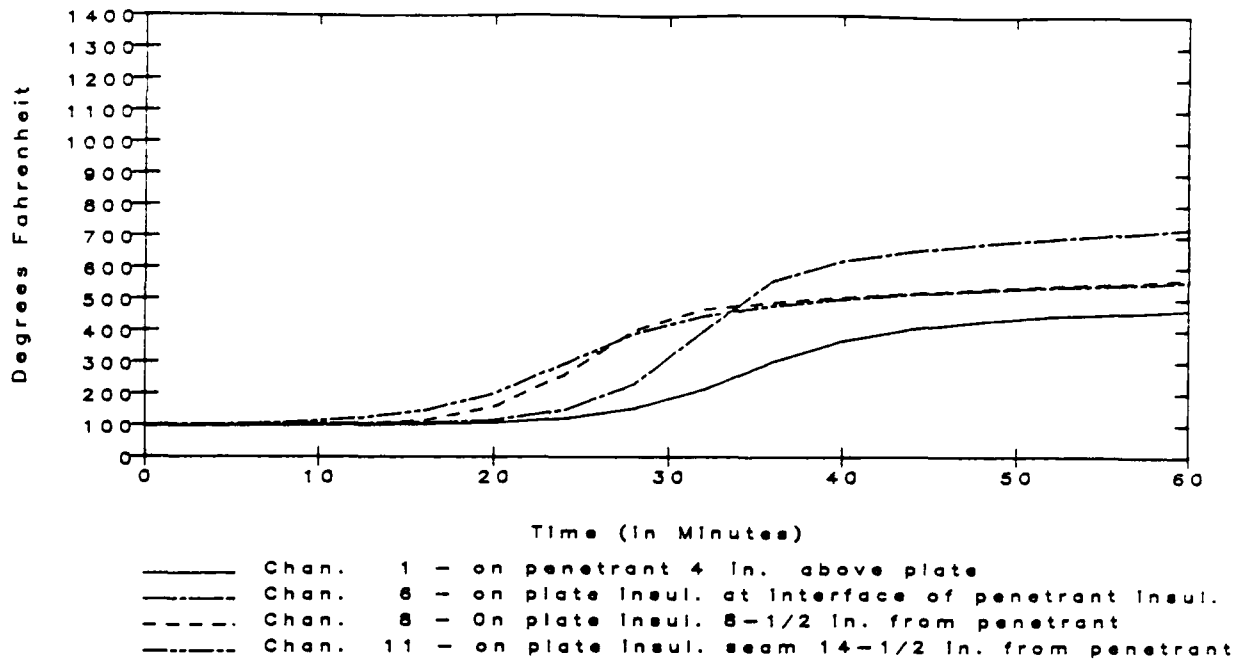


FIGURE 15. Temperatures on Copper Penetration Failures (D4/A-60U, D5/A-60U) During Class A-60 Test

SAMPLE D6/A60U



SAMPLE D9/A60U

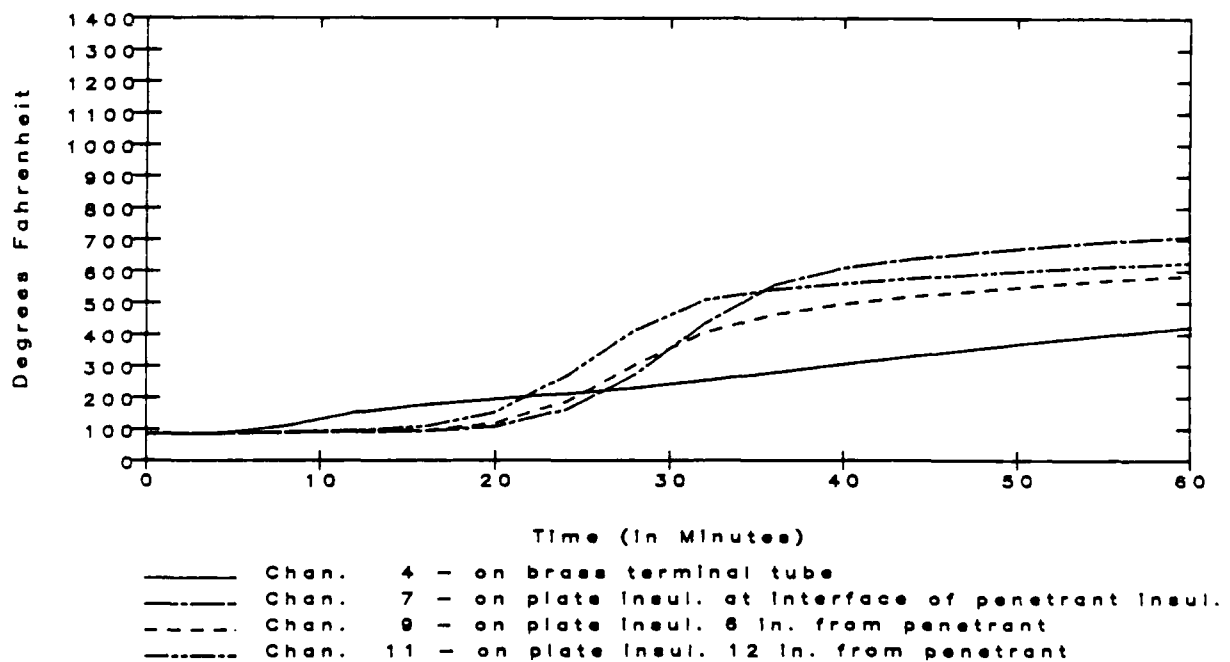
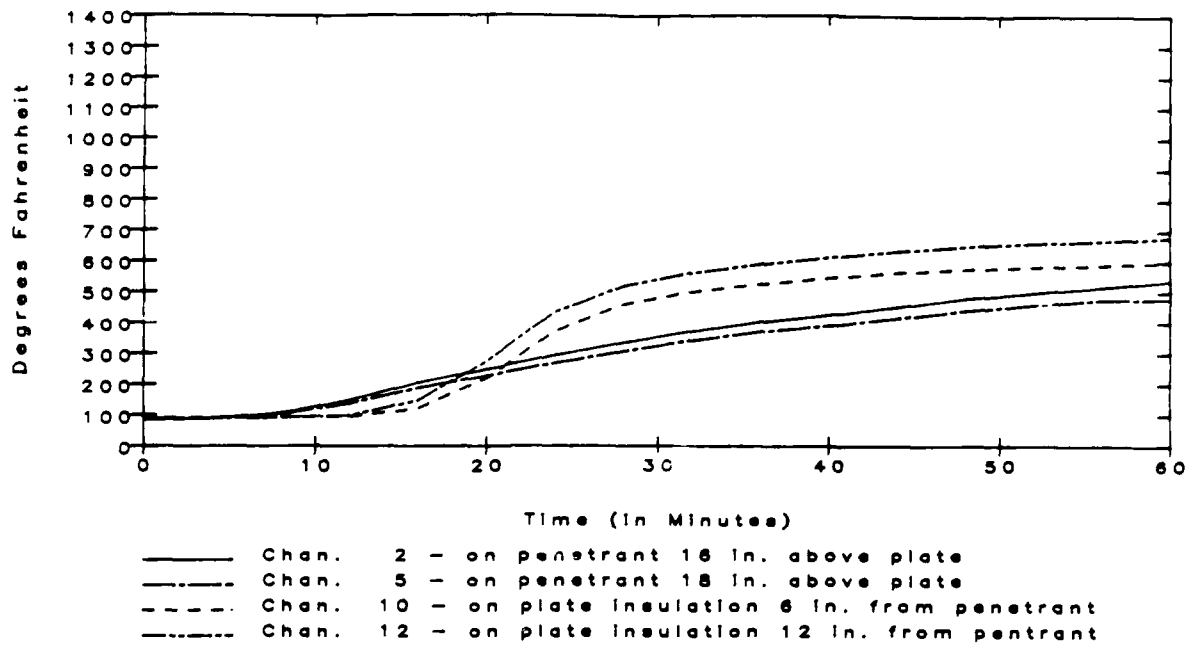


FIGURE 16. Temperatures on Copper Penetration Failures (D6/A-60U, D9/A-60U) During Class A-60 Test

SAMPLE D10/A60U



SAMPLE D11/A60U

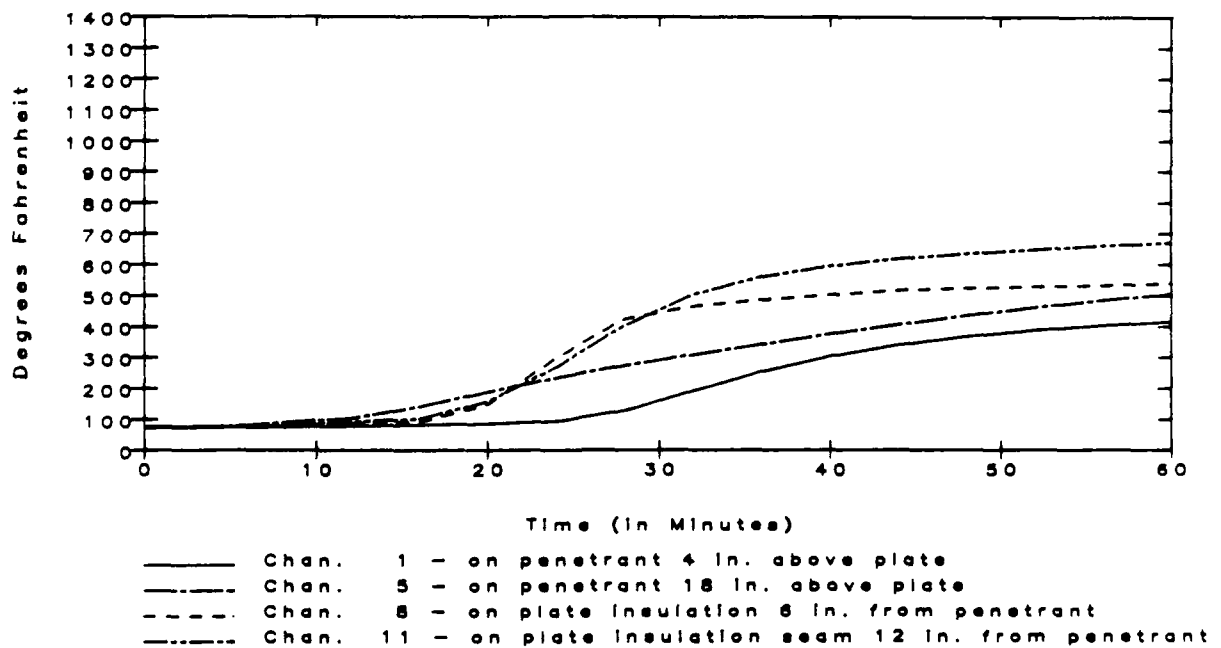
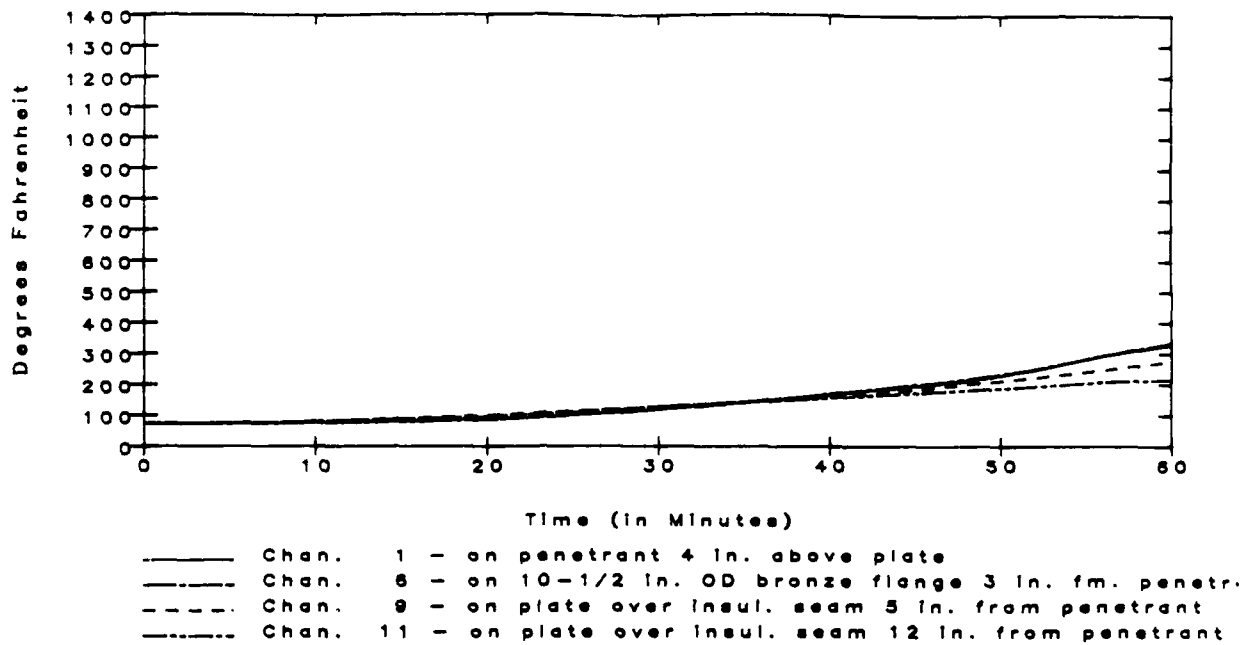


FIGURE 17. Temperatures on Copper Penetration Failures (D10/A-60U, D11/A-60U) During Class A-60 Test

SAMPLE D4/A60E



SAMPLE D4/A60U

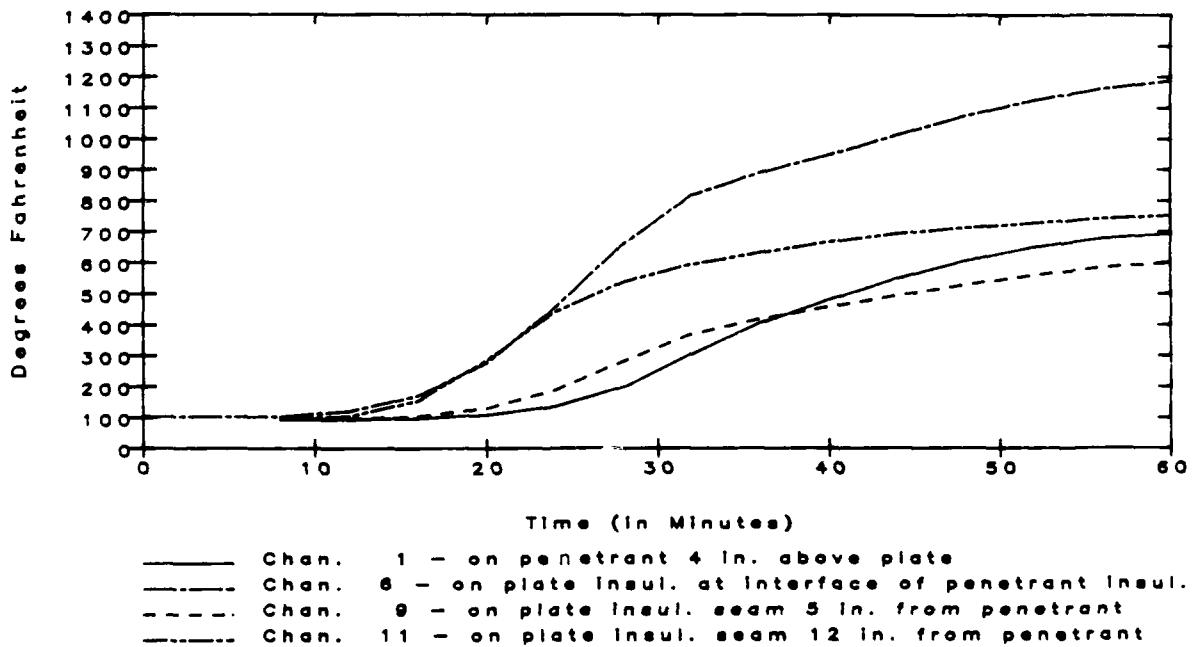
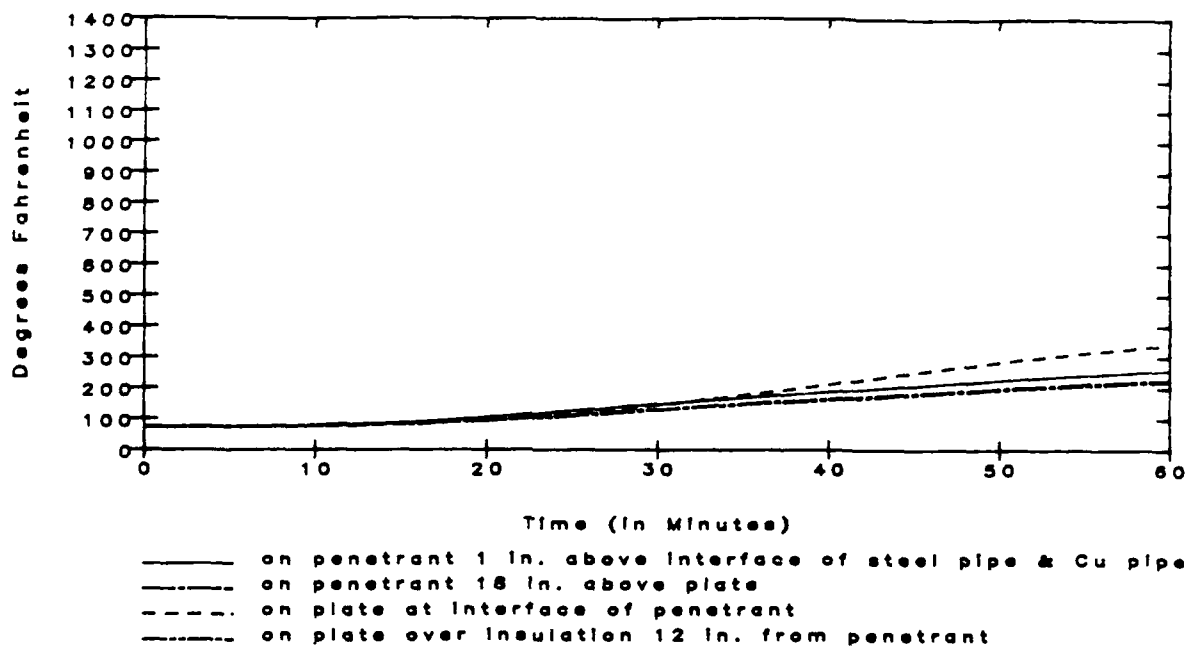


FIGURE 18. Temperatures on Copper Penetrations (D4/A-60E, D4/A-60U) During Class A-60 Test

SAMPLE D10/A60E



SAMPLE D10/A60U

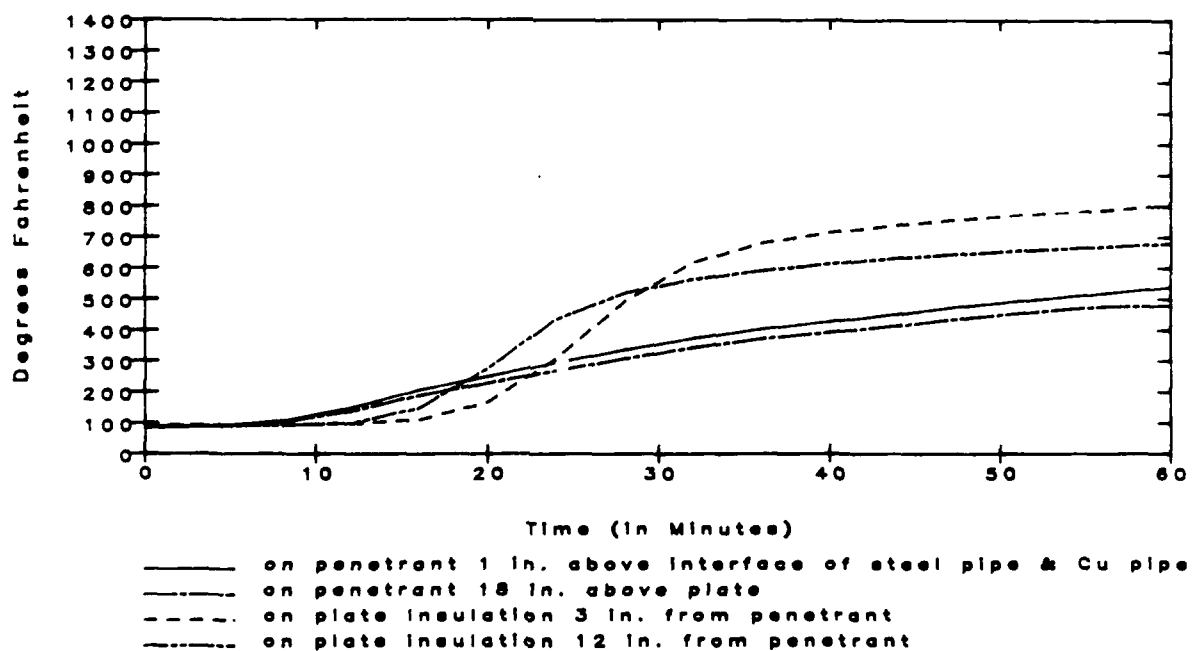


FIGURE 19. Temperatures on Copper Penetrations (D10/A-60E, D10/A-60U) During Class A-60 Test

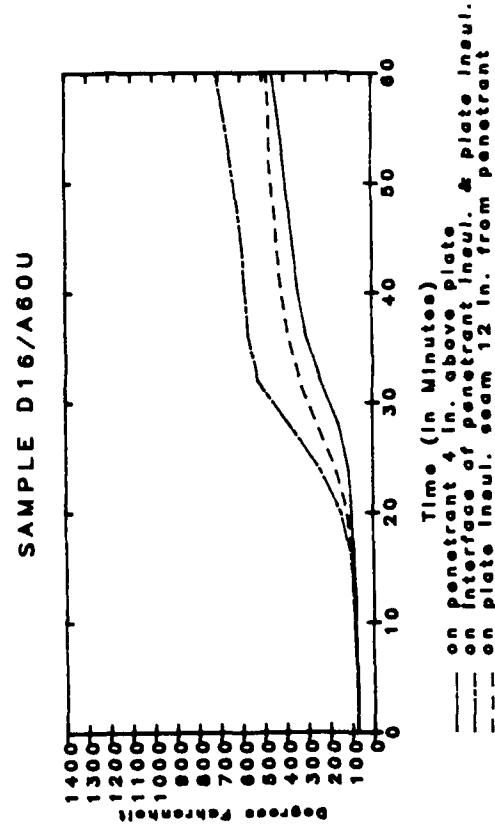
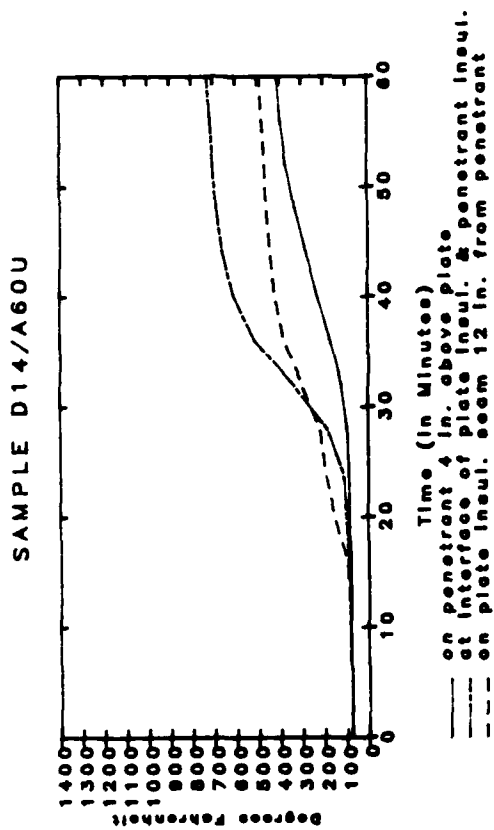
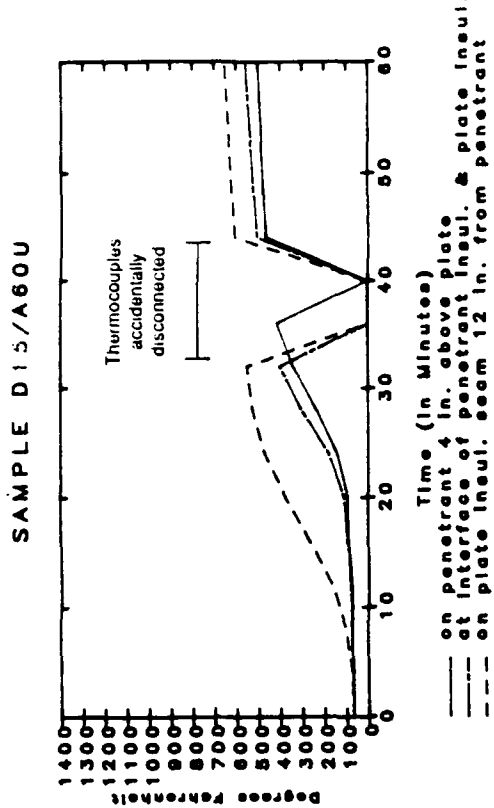
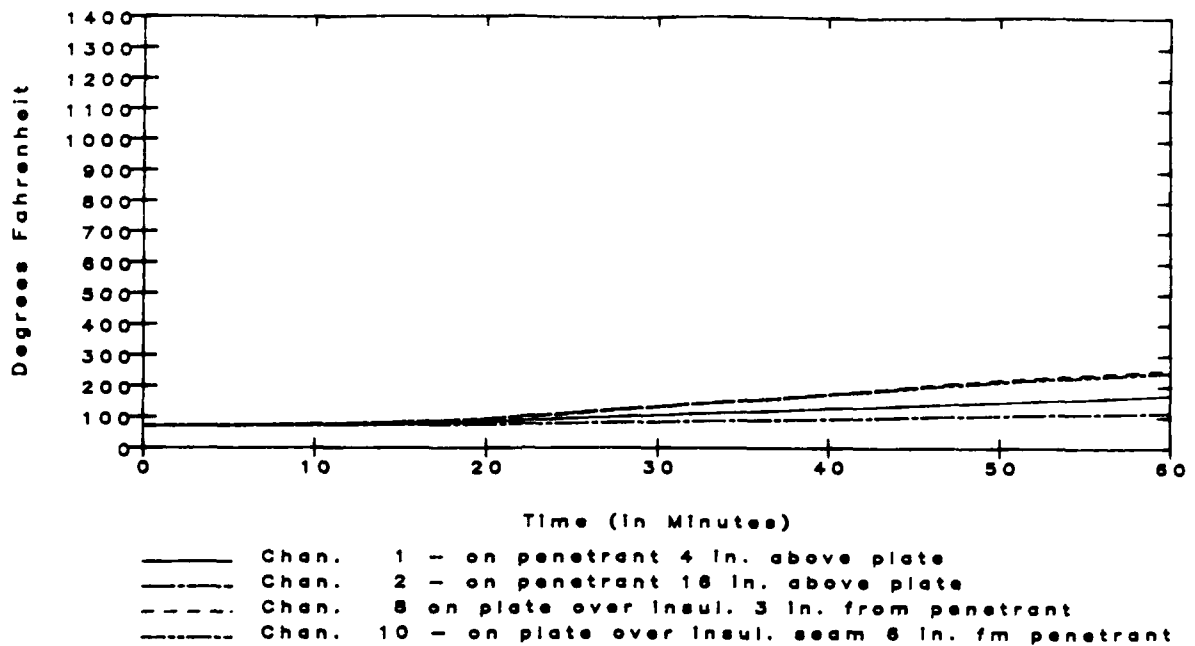


FIGURE 20. Temperatures on PVC Penetration Failures (D14/A-60U, D15/A-60U, D16/A-60U) During Class A-60 Test

SAMPLE D14/A60E



SAMPLE D14/A60U

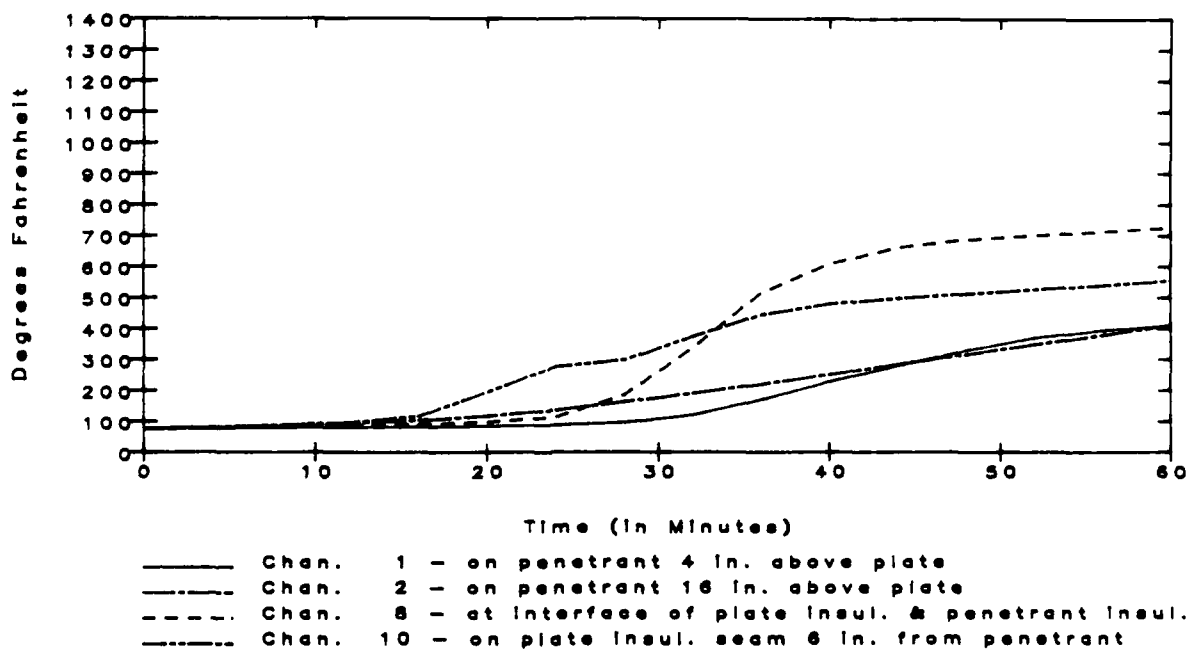


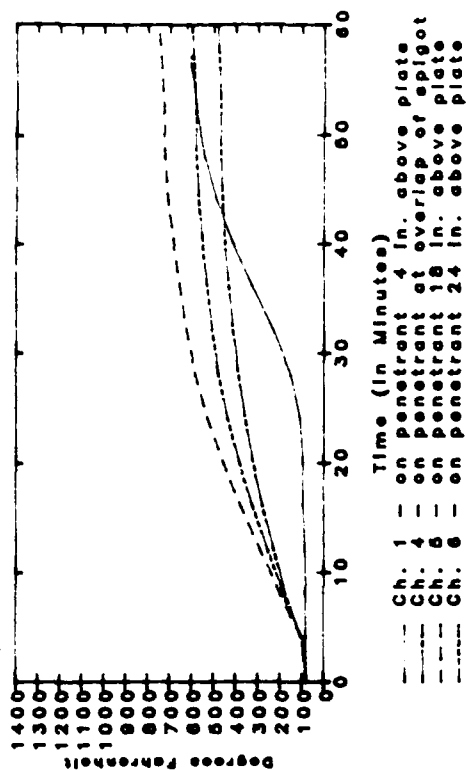
FIGURE 21. Temperatures on PVC Penetration (D14/A-60E, D14/A-60U) During Class A-60 Test

that insulating the fire side provides a greater degree of protection against excessive heat transmission.

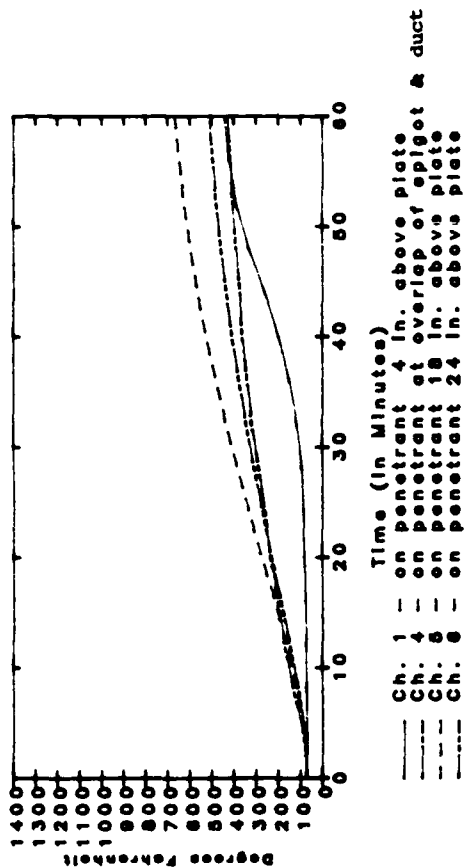
Six ventilation duct penetrations, two each of three different types, were tested. Three penetrations (one each of the three different types) were insulated on the non-fire side and the remaining three penetrations were insulated on the fire side. All six penetrations failed the temperature requirements for a Class A-60 rating. The temperature plots in Figure 22 show that the temperature rise for the three penetrations insulated on the non-fire side was above the acceptable limits for a Class A-60 rating. The temperature plots in Figure 23 show that the temperature rise for the three penetrations insulated on the fire side was above the acceptable limit for a Class A-60 rating. The test data in Appendix C for these six penetrations shows that the three penetrations insulated on the non-fire side failed the temperature requirements on both the penetrant insulation and deck plate insulation. Only two of the penetrations insulated on the fire side failed to meet the temperature requirements on the penetrant insulation and deck plate insulation whereas, the third penetration failed the temperature requirements on just the penetrant insulation.

Eleven electrical cable penetrations were tested. The brass terminal tube used in seven of these penetrations was missing its interior o-ring fitting. Fire retardant oakum was used in place of the missing o-rings. Five of the penetrations were insulated on the non-fire side, three were insulated on the exposed fire side, and three were only partially insulated on the test plate. The temperature plots in Figures 24 and 25 show that the temperature requirements for a Class A-60 rating were exceeded for the five penetrations insulated on the non-fire side. The three penetrants insulated on the fire side passed the temperature requirements for a Class A-60 rating, but two of the penetrants (D23/A-60E and D24/A60E) did fail the additional requirement of preventing the passage of smoke. The three penetrations partially insulated over either one side or both sides of the steel plate failed the temperature requirements for a Class A-60 rating. The penetrations represented in Figures 25 and 26 are identical in construction and differ only in the location of the insulation. It is interesting to note that the three penetrations in Figure 26 were insulated on the fire side and passed the temperature requirements for a Class A-60 rating, whereas the five penetrations in Figure 25 were insulated on the non-fire side and failed the temperature requirements for this rating. Figure 27 shows the temperature plots at three heights on cables in the three partially insulated penetrations. This figure shows that the penetration sample D19/A-60-3E & 3U, insulated on both sides of the steel plate, provided the lowest temperatures at a 6-inch (15.2 cm) height on the cables whereas the penetration sample D19/A-60-6U, insulated on the non-fire side, provided the highest temperatures at the 6-inch (15.2 cm) height on the cables.

SAMPLE D25/A60U



SAMPLE D17/A60U



SAMPLE D26/A60U

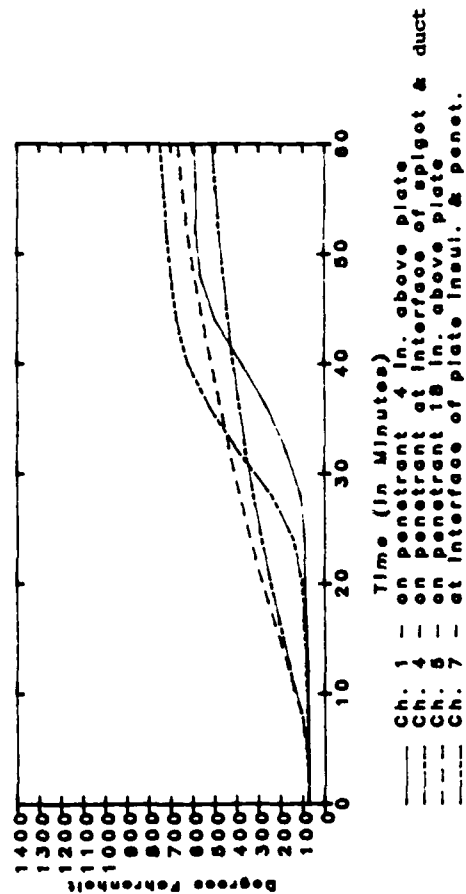
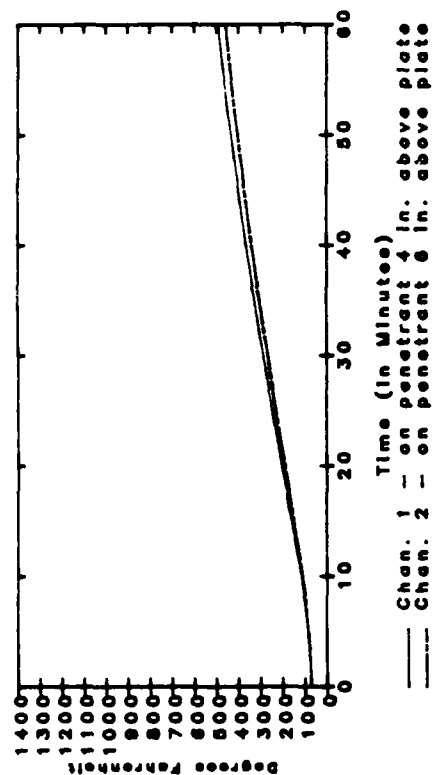
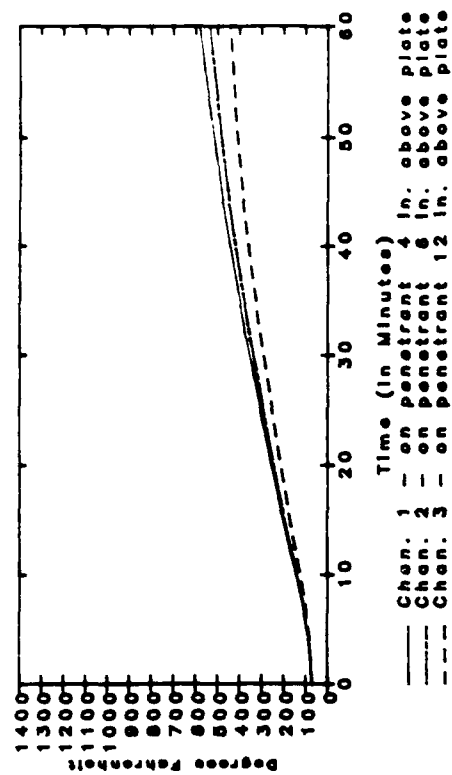


FIGURE 22. Temperatures on Ventilation Duct Failures (D17/A-60U, D25/A-60U, D26/A-60U) During Class A-60 Test

SAMPLE D17/A60E



SAMPLE D25/A60E



SAMPLE D26/A60E

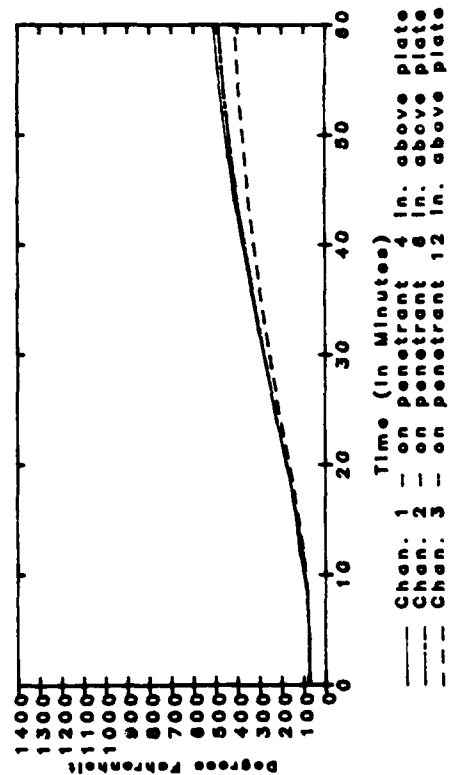
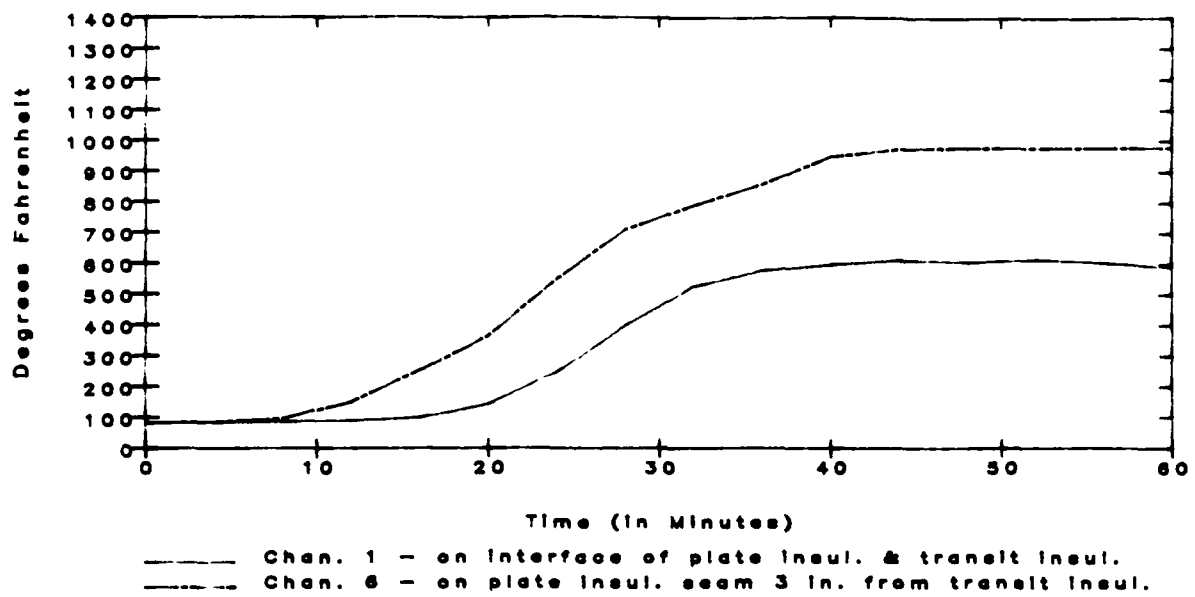


FIGURE 23. Temperatures on Ventilation Duct Failures (D17/A-60E, D25/A-60E, D26/A-60E) During Class A-60 Test

SAMPLE D19/A60U



SAMPLE D21/A60U

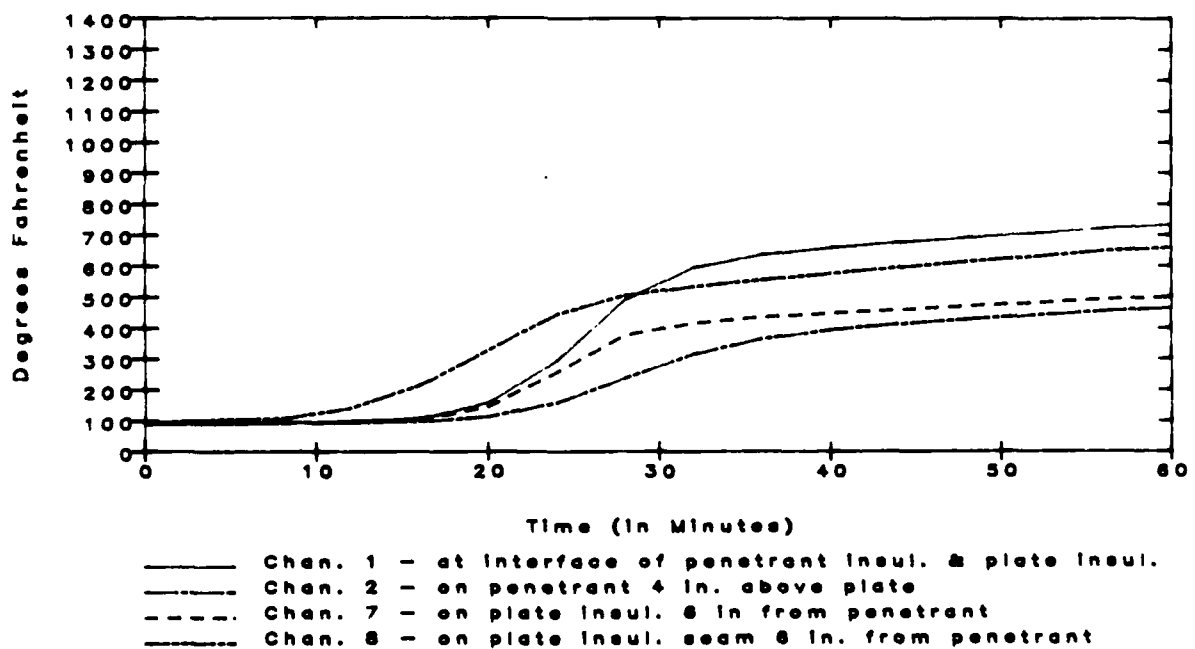


FIGURE 24. Temperatures on Electrical Cable Failures (D19/A-60U, D21/A-60U) During Class A-60 Test

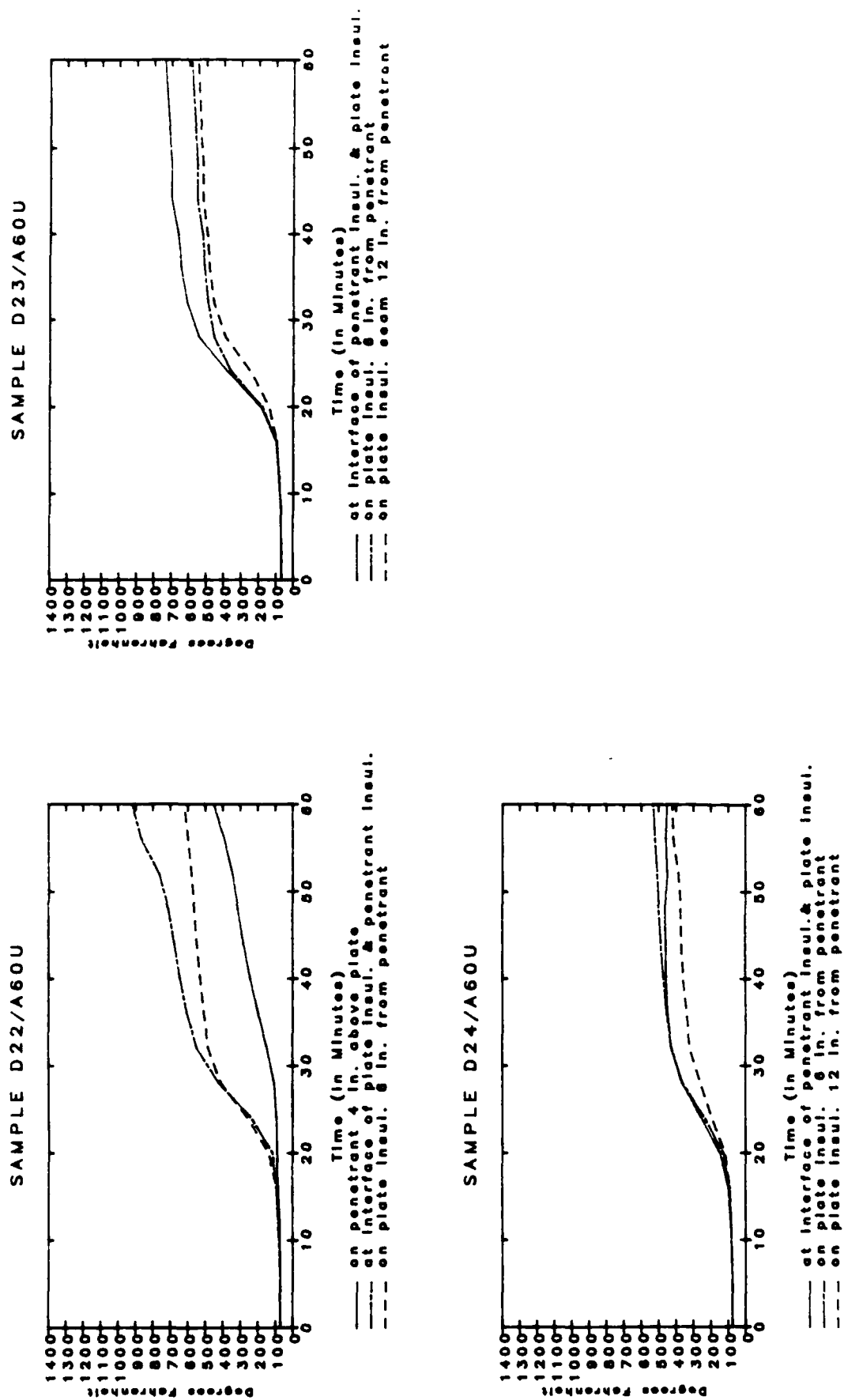
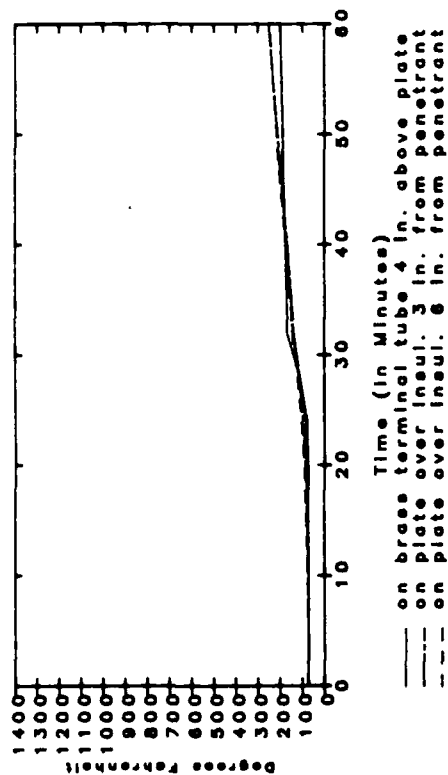
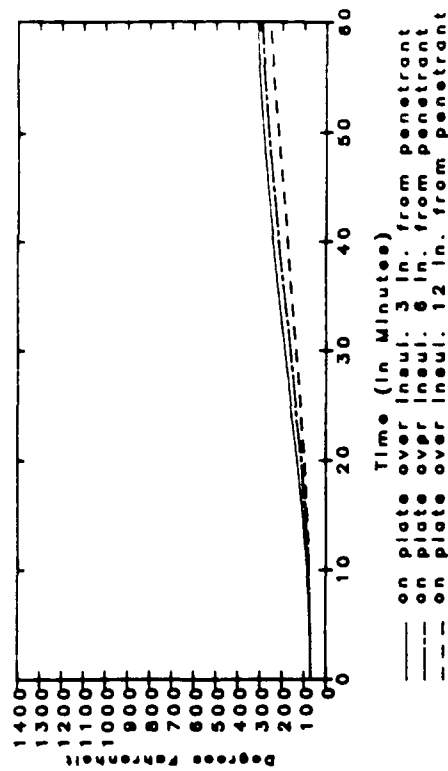


FIGURE 25. Temperatures on Electrical Cable Failures (D22/A-60U, D23/A-60U, D24/A-60U) During Class A-60 Test

SAMPLE D22/A60E



SAMPLE D23/A60E



SAMPLE D24/A60E

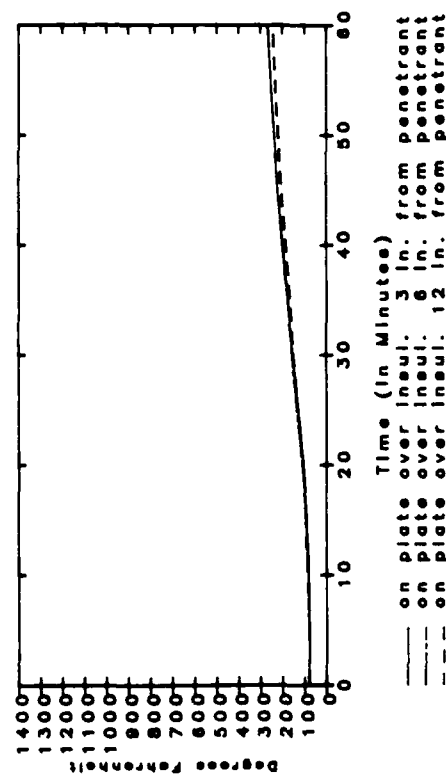


FIGURE 26. Temperatures on Electrical Cables Passing the Class A-60 Test

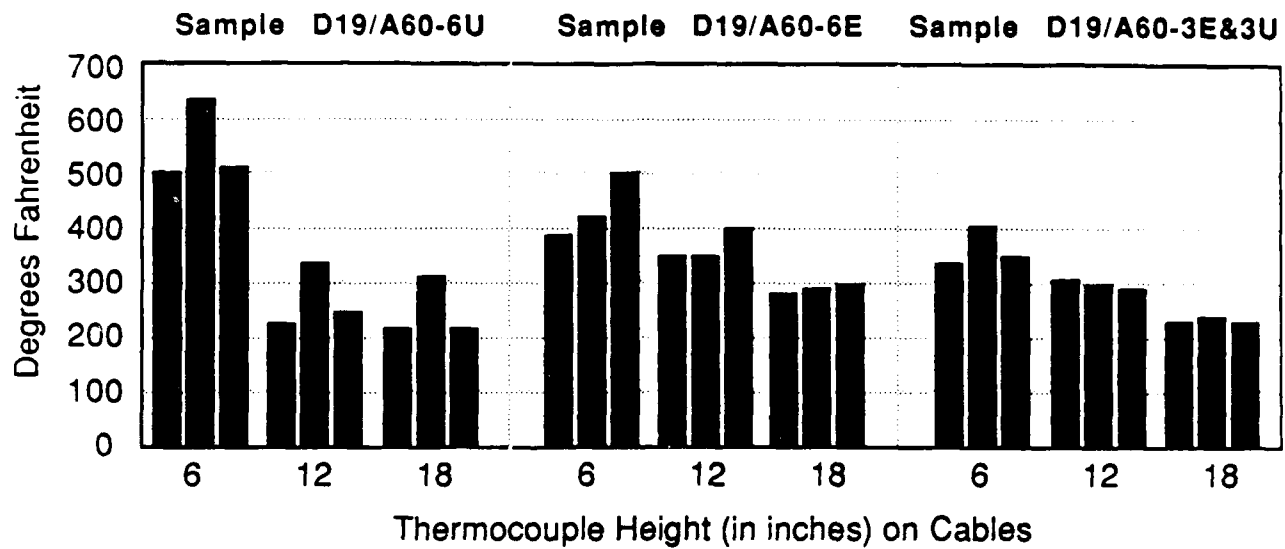


FIGURE 27. Temperatures on Partially Insulated Penetrations

7.0 CONCLUSIONS

The test data in Table 2 show that 3 of 9 samples insulated on the exposed side failed the temperature requirements for a Class A-60 rating, whereas all 18 samples insulated on the unexposed side failed to meet the temperature rise requirements for this rating. This indicates that, in general, insulating the exposed side provides a greater degree of protection than insulating the unexposed side. Tables 3-8 list the specific fire rating obtained by each penetration.

The following paragraphs provide a description of each penetration and its fire rating performance as a Class A or Class B fire stop when installed in a steel deck or bulkhead.

Penetration D3/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of a flanged steel spigot having 5 1/2-inch (14 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel plate. This penetration assembly will provide a Class A-0 fire rating.

Penetration D4/A-60U----A Class A-60 fire rating will not be provided by 18 inches (45.7 cm) of approved structural insulation extending up the non-fire side of a bronze flanged copper spigot which has 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) bronze plate and is bolted to a bronze flanged copper pipe. This penetration assembly will provide a Class A-15 fire rating.

Penetration D4/A-60E----A Class A-60 fire rating will be provided by 18 inches (45.7 cm) of approved structural insulation extending down the fire side of the penetrant.

Penetration D5/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of a bronze flanged copper spigot which has 5 1/2-inch (14 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel collar and is bolted to a bronze flanged copper pipe. This penetration assembly will provide a Class A-15 fire rating.

Penetration D6/A-60U----A Class A-60 fire rating will not be provided by 18 inches (45.7 cm) of approved structural insulation extending up the non-fire side of a bronze flanged copper spigot which has 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel collar and is bolted to a bronze flanged copper pipe. This penetration assembly will provide a Class A-15 fire rating.

Penetration D9/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of a continuous copper pipe in a steel spigot which has a 3-inch (7.6 cm) extension on the fire exposed side of a 3/16-inch (0.5 cm) and a 15-inch (38.1 cm) extension and a terminal tube on the non-fire side of the plate. This penetration assembly will provide a Class A-15 fire rating.

Penetration D10/A-0----A Class A-0 fire rating will be provided by a continuous copper pipe in a steel spigot which has 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel plate and a terminal tube on the fire side of the plate.

Penetration D10/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the D10/A-0 penetrant. This penetration assembly will provide a Class A-15 fire rating.

Penetration D10/A-60E----A Class A-60 fire rating will be provided by 15 inches (38.1 cm) of approved structural insulation extending down the fire side of the penetrant.

Penetration D11/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of a continuous pipe brazed at both ends of a steel spigot which has 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel plate. This penetration assembly will provide a Class A-15 fire rating.

Penetration D14/A-0----A Class A-0 fire rating will be provided by a steel spigot which has 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel plate and is threaded to a PVC pipe.

Penetration D14/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the penetrant. This penetration assembly will provide a Class A-30 fire rating.

Penetration D14/A-60E----A Class A-60 fire rating will be provided by 15 inches (38.1 cm) of approved structural insulation extending down the fire side of the penetrant.

Penetration D15/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of a continuous PVC pipe in a steel spigot which has 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel plate and is packed with fire sealant to a 1-inch (2.5 cm) depth in both ends of the spigot. This penetration assembly will provide a Class A-15 fire rating.

Penetration D16/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of a continuous PVC pipe in a steel spigot which has 3-inch (7.6 cm) extensions on both sides of 3/16-inch (0.5 cm) steel plate and is packed with fire sealant to a 1-inch (2.5 cm) depth in both ends of the spigot. This penetration assembly will provide a Class A-15 fire rating.

Penetration D17/A-0----A Class A-0 fire rating will be provided by a 12-inch (30.5 cm) diameter steel spigot which has a 6-inch (15.2 cm) extension on the fire side, and a 30-inch (76.2 cm) extension on the non-fire side and is flanged and bolted at both ends to a steel flange that is welded all around to a 12-inch (30.5 cm) diameter gauge duct with a 22 gauge cap on both ends.

Penetration D17/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the D17/A-0 penetrant. This penetration assembly will provide a Class A-15 fire rating.

Penetration D17/A-60E----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending down the fire side of the D17/A-0 penetrant. This penetration assembly will provide a Class A-30 fire rating.

Penetration D19/A-60U----A Class A-60 fire rating will not be provided by 9 inches (22.9 cm) of approved structural insulation extending up the non-fire side of a multiple cable transit penetrating a 3/16-inch (0.5 cm) steel plate. This penetration assembly will provide a Class A-15 fire rating.

Penetration D19/A-60-6U----A Class A-60 fire rating will not be provided by 6 inches (15.2 cm) of approved structural insulation extending up the non-fire side of the penetrant and covering only a 6-inch (15.2 cm) square area around the cable transit device on the non-fire side of the 3/16-inch (0.5 cm) steel plate. Note: Three inches (7.6 cm) of insulation did not cover the entire surface of the steel plate. This penetration assembly will provide a Class B-15 fire rating.

Penetration D19/A-60-6E----A Class A-60 fire rating will not be provided by 6 inches (15.2 cm) of approved structural insulation extending down the penetrant and covering only a 6-inch (15.2 cm) square area around the cable transit device on the fire side of the penetrant. Note: Three inches (7.6 cm) of insulation did not cover the entire surface of the steel plate. This penetration assembly will provide a Class B-15 fire rating.

Penetration D19/A-60-3E&3U----A Class A-60 fire rating will not be provided by 3 inches (7.6 cm) of approved structural insulation which extends up the penetrant on the non-fire side and 6 inches (15.2 cm) beyond the cable transit device on the non-fire side of the steel plate and by 3 inches (7.6 cm) of approved structural insulation which extends down the fire side of the penetrant and only 6 inches (15.2 cm) beyond the cable transit device on the fire side of the steel plate. Note: There was no 3-inch (7.6 cm) layer of insulation across the entire surface of the unexposed fire side of the steel plate. This penetration assembly will provide a Class B-15 fire rating.

Penetration D21/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation which extends up the non-fire side of a steel spigot which has a 3-inch (7.6 cm) extension on the fire side of a 3/16-inch (0.5 cm) steel plate and a 15-inch (38.1 cm) extension with a terminal tube on the unexposed fire side. This penetration assembly will provide a Class A-15 fire rating.

Penetration D22/A-0----A Class A-0 fire rating will not be provided by a steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The spigot had a 3-inch (7.6 cm) extension with a terminal tube on the unexposed fire side and was welded all around to a 3/16-inch (0.5 cm) steel plate and also had a 90 degree bend on its fire side. This penetration assembly will provide a Class B-0 fire rating.

Penetration D22/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the penetrant. This penetration assembly will provide a Class A-15 fire rating.

Penetration D22/A-60E----A Class A-60 fire rating will be provided by 15 inches (38.1 cm) of approved structural insulation extending down the fire side of the penetrant.

Penetration D23/A-0----A Class A-0 fire rating will be provided by a continuous 2 inch (5.1 cm) diameter marine electrical cable in a steel spigot which has 15 inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel plate, is welded all around to the plate, has a terminal tube on the non-fire side and has fire sealant packed inside both ends to a 1 inch (2.5 cm) depth.

Penetration D23/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the penetrant. This penetration assembly will provide a Class A-15 fire rating.

Penetration D23/A-60E----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending down the fire side of the penetrant. This penetration assembly will provide a Class B-15 fire rating.

Penetration D24/A-0----A Class A-0 fire rating will not be provided by a continuous 2-inch (5.1 cm) diameter marine electrical cable in a steel spigot which has 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel plate, is welded all around to the plate, has a terminal tube on the fire side, and has fire sealant packed inside both ends to a 1-inch (2.5 cm) depth. This penetration assembly will provide a Class B-0 fire rating.

Penetration D24/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the penetrant. This penetration assembly will provide a Class B-15 fire rating.

Penetration D24/A-60E----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved insulation extending down the fire side of the penetrant. This penetration assembly will provide a Class B-15 fire rating.

Penetration D25/A-0----A Class A-0 fire rating will be provided by a 12 inch x 12 inch (30.5 cm x 30.5 cm) steel spigot which is welded all around to a 3/16-inch (0.5 cm) steel plate and has a 6-inch (15.2 cm) extension on the fire side and a 30-inch (76.2 cm) extension on the non-fire side with both extensions being flanged and bolted at the ends to a steel flange welded to a 22 gauge duct with end caps.

Penetration D25/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the D25/A-0 penetrant. This penetration assembly will provide a Class A-0 fire rating.

Penetration D25/A-60E----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending down the fire side of the D25/A-0 penetrant. This penetration assembly will provide a Class A-30 fire rating.

Penetration D26/A-0----A Class A-60 fire rating will be provided by a continuous 12-inch (30.5 cm) diameter 22 gauge duct in a 12 1/2-inch (31.8 cm) diameter steel spigot which has a 6-inch (15.2 cm) extension on the fire side and a 30-inch (76.2 cm) extension on the unexposed fire side, is welded all around to a 3/16-inch (0.5 cm) steel plate and is packed with fire sealant inside both ends around the duct to a 1-inch (2.5 cm) depth.

Penetration D26/A-60U----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending up the non-fire side of the penetrant. This penetration assembly will provide a Class A-15 fire rating.

Penetration D26/A-60E----A Class A-60 fire rating will not be provided by 15 inches (38.1 cm) of approved structural insulation extending down the fire side of the penetrant. This penetration assembly will provide a Class A-30 fire rating.

8.0 RECOMMENDATIONS

8.1 Penetration Designs

In general it is recommended that the ASTM E814/UL 1479 method be considered as a fire resistance performance test for approving penetration designs submitted to the U.S. Coast Guard. Both standards would require some modifications (see section 8.2) to comply with specific U.S. Coast Guard regulations governing the passage of smoke and the acceptable limits for temperature rise.

It is recommended that the configurations of penetrations which successfully passed the ASTM E814/UL 1479 test be published as design guidelines. Based on the test results, samples which conform to these configurations could be expected to pass the modified ASTM E814/UL 1479 performance test.

It is recommended that penetrations be insulated on the side of the deck or bulkhead which is most likely to be exposed to a fire, thus providing the most protection against heat transmission.

It is recommended that additional testing be conducted with penetrating items and fire stop material from these tests installed in Class B bulkhead or deck plate material to evaluate specimen suitability for marine use.

8.2 Approval Test Procedures

The data sheet for the fire performance test should report the time and extent of smoke occurrence on the unexposed side of the sample, and should indicate the path by which the smoke reached the unexposed side.

The number of thermocouples required by ASTM E814/UL 1479 on the penetrant should be increased from one to two. This redundancy should be provided at critical locations.

The test documentation requirements should include videotaping the testing. This tape would be included when a penetration is submitted for Coast Guard acceptance and could be used to verify whether there was passage of smoke, flame or water through the penetrant.

REFERENCES

1. Beene, Jr., David, and Howes, Jack. Fire Resistance Testing of Bulkhead and Deck Penetrations, Department of Transportation, U. S. Coast Guard, October, 1985.
2. U.S. Government Printing Office. Code of Federal Regulations, Title 46 CFR 72.05-10, 1987.
3. American Society for Testing and Materials. Standard Methods of Fire Tests of Building Construction and Materials, ASTM E-119-83; Annual Book of ASTM Standards, Vol. 04.07, 1983.
4. American Society for Testing and Materials. Standard Method of Fire Tests of Through-Penetration Fire Stops, ASTM E-814-83; Annual Book of ASTM Standards, Vol. 04.07, 1983.
5. Underwriters Laboratories, Inc., UL 1479, Standard for Fire Tests of Through-Penetration Firestops; First Edition, January 1983.
6. Department of Transportation, U.S. Coast Guard. Navigation and Vessel Inspection Circular 6-80, April 1980.
7. Transport Canada Coast Guard. Structural Fire Protection Standards: Specifications, Procedures, and Testing TP 439; Ship Safety Branch.
8. Department of Transportation, U.S. Coast Guard, Miscellaneous Electrical Equipment List CG-293, 1962.
9. U.S. Government Printing Office. Code of Federal Regulations, Title 46 CFR 164.007, 1987.

APPENDIX A
DESCRIPTION OF SAMPLE PENETRATIONS

In all sample penetration descriptions, spigot refers to a length of pipe which either replaces or encloses a continuous run of pipe, duct, or electrical cable. A detailed drawing and material description of each sample penetration is included in the individual data sections in Appendix C.

Class A-0 Samples

| <u>Sample</u> | <u>Description</u> |
|---------------|---|
| D10/A-0 | A continuous copper pipe in a steel spigot. The steel spigot had 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel test plate and a terminal tube on its fire side. The steel spigot was welded all around to the test plate. |
| D14/A-0 | A steel spigot threaded at both ends to PVC pipe. The steel spigot had 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel test plate and was welded all around to the test plate. |
| D17/A-0 | A 12-inch (30.5 cm) diameter steel spigot flanged and bolted at both ends to a steel flange welded all the way around to a 12-inch (30.5 cm) diameter 22 gauge duct with a 22 gauge blank end cap on both ends. The spigot had a 6-inch (15.2 cm) extension on the fire side, a 30-inch (76.2 cm) extension on the non-fire side, and was welded all around to a 3/16-inch (0.5 cm) steel test plate. |
| D22/A-0 | A curved steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The steel spigot had a 90° bend from a 5-inch (12.7 cm) radius on the fire side and was welded all around to a 3/16-inch (0.5 cm) steel test plate. The steel spigot had a 3-inch (7.6 cm) terminal tube on the non-fire side of the test plate. The electrical cable complied with Canadian Coast Guard Ship Safety Electrical Standards. |

Class A-0 Samples (cont'd.)

- D23/A-0 A steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The steel spigot was welded all around to a 3/16-inch (0.5 cm) steel test plate and had a 15-inch (38.1 cm) extension on the fire side of the plate. The steel spigot had a 15-inch (38.1 cm) extension and a terminal tube on the non-fire side of the test plate. Fire sealant was packed inside both ends of the spigot around the electrical cable to a 1-inch (2.5 cm) depth. The electrical cable complied with Canadian Coast Guard Ship Safety Electrical Standards.
- D24/A-0 A steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The steel spigot was welded all around to a 3/16-inch (0.5 cm) steel test plate and had a 15-inch (38.1 cm) extension on the non-fire side of the plate. The steel spigot had a 15-inch (38.1 cm) extension and a terminal tube on the fire side of the test plate. Fire sealant was packed inside both ends of the spigot around the cable to a 1-inch (2.5 cm) depth. The electrical cable complied with Canadian Coast Guard Ship Safety Electrical Standards.
- D25/A-0 A 12x12-inch (30.5 x 30.5 cm) steel spigot flanged and bolted at both ends to a steel flange 12x12-inches (30.5 x 30.5 cm) welded all around to 22 gauge duct with a 22 gauge blank end cap on both ends. The spigot had a 6-inch (15.2 cm) extension on the fire side, a 30-inch (76.2 cm) extension on the non-fire side, and was welded all around to a 3/16-inch (0.5 cm) steel test plate.
- D26/A-0 A continuous 12-inch (30.5 cm) diameter 22 gauge duct inside a 12 1/2-inch (31.8 cm) diameter steel spigot. The duct had a 22 gauge end cap on both ends. The steel spigot had a 6-inch (15.2 cm) extension on the fire side, a 30-inch (76.2 cm) extension on the non-fire side, and was welded all around to a 3/16-inch (0.5 cm) steel test plate. Fire sealant was packed inside both ends of the spigot around the duct to a 1-inch (2.5 cm) depth.

Class A-60E Samples

The letter E indicates that the insulation was attached to the fire side of the test plate and the penetrant. The insulation details are shown on the drawings in the appropriate data sections of Appendix C.

| <u>Sample</u> | <u>Description</u> |
|---------------|--|
| D4/A-60E | A bronze flanged copper spigot (with 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) bronze plate) bolted to a bronze flanged copper pipe. The bronze plate is brazed all around to the copper spigot and bolted to a 3/16-in (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the fire side of the test plate and 18 inches (45.7 cm) of insulation extended down the penetrant's fire side. |
| D10/A-60E | Same as D10/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 15 inches (38.1 cm) of insulation extended down the penetrant's fire side. |
| D14/A-60E | Same as D14/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 15 inches (38.1 cm) of insulation extended down the penetrant's fire side. |
| D17/A-60E | Same as D17/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 15 inches (38.1 cm) of insulation extended down the penetrant's fire side. |
| D22/A-60E | Same as D22/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 18 inches (45.7 cm) of insulation extended down the penetrant's fire side. |
| D23/A-60E | Same as D23/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 15 inches (38.1 cm) of insulation extended down the penetrant's fire side. |

Class A-60E Samples (cont'd.)

- D24/A-60E Same as D24/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 15 inches (38.1 cm) of insulation extended down the penetrant's fire side.
- D25/A-60E Same as D25/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 15 inches (38.1 cm) of insulation extended down the penetrant's fire side.
- D26/A-60E Same as D26/A-0 except that 3 inches (7.6 cm) of insulation covered the fire side of the test plate and 15 inches (38.1 cm) of insulation extended down the penetrant's fire side.

Class A-60U Samples

The letter U indicates that the insulation was attached to the non-fire side of the test plate and the penetrant. The insulation details are shown on the drawings in the appropriate data sections of Appendix C.

| <u>Sample</u> | <u>Description</u> |
|---------------|---|
| D3/A-60U | A flanged steel spigot (with 5 1/2-inch (14 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel collar) bolted to a bronze flanged copper pipe. The steel collar is welded all the way around to both the steel spigot and to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the steel plates' non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant. |
| D4/A-60U | A bronze flanged copper spigot (with 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) bronze plate) bolted to a bronze flanged copper pipe. The bronze plate is brazed all around to the copper spigot and bolted to a 3/16-inch (0.5 cm) steel collar which is welded to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 18 inches (45.7 cm) of insulation extended up the penetrant. |

Class A-60U Samples (cont'd.)

- D5/A-60U A bronze-flanged copper spigot (with 5 1/2-inch (14 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel collar) bolted to a bronze flanged copper pipe. The steel collar is brazed all around to the copper spigot and welded all around to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.
- D6/A-60U A bronze-flanged copper spigot (with 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel collar) bolted to a bronze flanged copper pipe. The steel collar is brazed all around to the copper spigot and welded all around to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 18 inches (45.7 cm) of insulation extended up the penetrant.
- D9/A-60U A continuous steel pipe in a steel spigot. The steel spigot had a 3-inch (7.6 cm) extension on the fire-exposed side of the 3/16-inch (0.5 cm) steel test plate and a 15-inch (38.1 cm) extension with a terminal tube on the unexposed fire side of the test plate. The steel spigot was welded all the way around to the test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.
- D10/A-60U A continuous copper pipe in a steel spigot. The steel spigot had 15-inch (38.1 cm) extension on both sides of a 3/16-inch (0.5 cm) steel test plate and a terminal tube on its fire side. The steel spigot was welded all the way around to the test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

Class A-60U Samples (cont'd.)

- D11/A-60U A continuous copper pipe in a steel spigot. The steel spigot had 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel test plate. The steel spigot was brazed all the way around at both its ends to the copper pipe while it was welded all the way around to the test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.
- D14/A-60U A steel spigot threaded at both ends to PVC pipe. The steel spigot had 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel test plate and was welded all around to the test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.
- D15/A-60U A continuous PVC pipe in a steel spigot. The steel spigot had 15-inch (38.1 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel test plate and welded all the way around to the plate. Fire sealant was packed inside both ends of the spigot around the PVC pipe to a 1-inch (2.5 cm) depth. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.
- D16/A-60U A continuous PVC pipe in a steel spigot. The steel spigot had 3-inch (7.6 cm) extensions on both sides of a 3/16-inch (0.5 cm) steel test plate and was welded all the way around the plate. Fire sealant was packed inside both ends of the spigot around the PVC pipe to a 1-inch (2.5 cm) depth. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

Class A-60U Samples (cont'd.)

D17/A-60U A 12-inch (30.5 cm) diameter steel spigot flanged and bolted at both ends to a steel flange welded all around to a 12-inch (30.5 cm) diameter 22 gauge duct. The duct had a 22 gauge blank end cap on both ends. The spigot had a 6-inch (15.2 cm) extension on the fire side, a 30-inch (76.2 cm) extension on the non-fire side, and was welded all around to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

D19/A-60U A multi-cable transit with six types of marine electrical cable complying with Canadian Coast Guard Ship Safety Electrical Standards. The transit device was welded all around to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 9 inches (22.9 cm) of insulation extended up the penetrant.

D21/A-60U A steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The steel spigot was welded all the way around to a 3/16-inch (0.5 cm) steel test plate and had a 3-inch (7.6 cm) extension on the fire-exposed side of the plate. The steel spigot had a 15-inch (38.1 cm) extension and a terminal tube on the non-fire side of the test plate. The electric cable complied with Canadian Coast Guard Ship Safety Electrical Standards. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

Class A-60U Samples (cont'd.)

D22/A-60U A curved steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The steel spigot had a 90° bend from a 5-inch (12.7 cm) radius on the fire side and was welded all around to a 3/16-inch (0.5 cm) steel test plate. The steel spigot had a 3-inch (7.6 cm) terminal tube on the unexposed fire side of the test plate. The electrical cable complied with Canadian Coast Guard Ship Safety Electrical Standards. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

D23/A-60U A steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The steel spigot was welded all around to a 3/16-inch (0.5 cm) steel test plate and had a 15-inch (38.1 cm) extension on the fire-exposed side of the plate. The steel spigot had a 15-inch (38.1 cm) extension and a terminal tube on the unexposed fire side of the test plate. The electrical cable complied with Canadian Coast Guard Ship Safety Electrical Standards. Fire sealant was packed inside both ends of the spigot around the electrical cable to a 1-inch (2.5 cm) depth. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

D24/A-60U A steel spigot and a terminal tube containing a 2-inch (5.1 cm) diameter marine electrical cable. The steel spigot was welded all around to a 3/16-inch (0.5 cm) steel test plate and had a 15-inch (38.1 cm) extension on the non-fire side of the plate. The steel spigot had a 15-inch (38.1 cm) extension and a terminal tube on the exposed fire side of the test plate. The electrical cable complied with Canadian Coast Guard Ship Safety Electrical Standards. Fire sealant was packed inside both ends of the spigot around the cable to a 1-inch (2.5 cm) depth. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

Class A-60U Samples (cont'd.)

- D25/A-60U A 12x12-inch (30.5 x 30.5 cm) steel spigot flanged and bolted at both ends to a steel flange welded all around to a 12x12-inch (30.5 x 30.5 cm) 22 gauge duct. The duct had 22 gauge blank end cap on both ends. The spigot had a 6-inch (15.2 cm) extension on the fire side, a 30-inch (76.2 cm) extension on the non-fire side, and was welded all around to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.
- D26/A-60U A continuous 12-inch (30.5 cm) diameter 22 gauge duct in a 12 1/2-inch (31.8 cm) diameter steel spigot. The duct had 22 gauge end caps on both ends. The steel spigot had a 6-inch (15.2 cm) extension on the fire side, a 30-inch (76.2 cm) extension on the non-fire side, and was welded all around to a 3/16-inch (0.5 cm) steel test plate. Fire sealant was packed inside both ends of the spigot around the duct to a 1-inch (2.5 cm) depth. Three inches (7.6 cm) of insulation covered the steel plate's non-fire side and 15 inches (38.1 cm) of insulation extended up the penetrant.

Samples Partially Insulated

| <u>Sample</u> | <u>Description</u> |
|---------------|--------------------|
|---------------|--------------------|

- | | |
|-------------|---|
| D19/A-60-6E | A multi-cable transit with six types of marine electrical cable complying with Canadian Coast Guard Ship Safety Electrical Standards. The transit device was welded all around to a 3/16 inch (0.5 cm) steel test plate. Six inches (15.2 cm) of insulation extended down the penetrant's fire side and covered an area on the steel plate which extended 6 inches (15.2 cm) beyond each side of the multi-cable transit. |
| D19/A-60-6U | Same as D19/A-60-6E except that the insulation was located on the non-fire side. |

Samples Partially Insulated (cont'd.)

D19/A-60-3E & 3U A multi-cable transit with six types of marine electrical cable complying with Canadian Coast Guard Ship Safety Electrical Standards. The transit device was welded all around to a 3/16-inch (0.5 cm) steel test plate. Three inches (7.6 cm) of insulation covered an area on the steel plate around the multi-cable transit on both the fire and non-fire sides. This area extended 6 inches (15.2 cm) beyond each side of the multi-cable transit.

APPENDIX B



Designation: E 814 - 83

AMERICAN SOCIETY FOR TESTING AND MATERIALS

1916 Race St., Philadelphia, Pa. 19103

Reprinted from the Annual Book of ASTM Standards, Copyright ASTM
If not listed in the current combined index, will appear in the next edition.

Standard Method of FIRE TESTS OF THROUGH-PENETRATION FIRE STOPS¹

This standard is issued under the fixed designation E 814; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Characteristically fire spreads from one building compartment to another by the collapse of a barrier, or by openings through which flames or hot gases may pass, or by transfer of sufficient heat to ignite combustibles beyond the barrier. ASTM Methods E 119, *Fire Tests of Building Construction and Materials*,² describe the method to be used to measure the fire-resistive performance of these barriers.

However, various techniques of providing for the distribution of services within a structure sometimes require that openings be made in fire-resistive walls and floors to allow the passage of such penetrating items as cables, conduits, pipes, trays, and ducts through to the adjacent compartment. Fire-stop material is installed into these openings to resist the spread of fire.

The performance of through-penetration fire stops should be measured and specified according to a common standard that describes the method of fire exposure and rating criteria.

1. Scope

1.1 This method is applicable to through-penetration fire stops of various materials and construction. Fire stops are intended for use in openings in fire-resistive walls and floors that are evaluated in accordance with Methods E 119.

1.2 Tests conducted in conformance with this method will record fire-stop performance during the test exposure; but such tests shall not be construed to determine suitability of the fire stop for use after test exposure.

1.3 This method considers the resistance of fire stops to an external force stimulated by a hose stream. However, this method shall not be construed as determining the performance of the fire stop during actual fire conditions when subjected to forces such as failure of cable support systems and falling debris.

1.4 The intent of this method is to develop data to assist others in determining the suitability of the fire stops for use where fire resistance is required.

1.5 This standard should be used to measure and describe the properties and materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

2. Applicable Document

2.1 ASTM Standard:

E 119 Methods of Fire Tests of Building Construction and Materials²

¹ This method is under the jurisdiction of Committee E-5 on Fire Standards and is the direct responsibility of Subcommittee E05.11 on Building Construction.

Current edition approved May 27, 1983. Published July 1983. Originally published as E 814-81. Last previous edition E 814-81.

² 1983 Annual Book of ASTM Standards, Vol 04.07



3. Summary of Method

3.1 This method of testing through-penetration fire stops exposes fire stops to a standard temperature-time fire, and to a subsequent application of a hose stream.

3.2 Ratings are established on the basis of the period of resistance to the fire exposure, prior to the first development of through openings, flaming on the unexposed surface, limiting thermal transmission criterion, and acceptable performance under application of a hose stream.

4. Significance and Use

4.1 This method is used to determine the performance of a fire stop with respect to exposure to a standard temperature-time fire test and hose stream test. The performance of a fire stop is dependent upon the specific assembly of materials tested including the number, type, and size of penetrations and the floors or walls in which it is installed.

4.2 Two ratings are established for each fire stop. An *F* rating is based upon flame occurrence on the unexposed surface, while the *T* rating is based upon the temperature rise as well as flame occurrence on the unexposed side of the fire stop. These ratings, together with detailed performance data such as the location of through-openings and temperatures of penetrating items are intended to be one factor in assessing performance of fire stops.

5. Terminology

5.1 Definition:

5.1.1 *fire stop*—a through-penetration fire stop is a specific construction consisting of the materials that fill the opening around penetrating items such as cables, cable trays, conduits, ducts, and pipes and their means of support through the wall or floor opening to prevent spread of fire.

5.2 Descriptions of Terms Specific to this Method:

5.2.1 *test sample*—the fire stop being tested.

5.2.2 *test assembly*—the wall or floor into which the test sample(s) is (are) mounted or installed.

6. Control of Fire Tests

6.1 *Temperature-Time Curve*—The fire environment within the furnace shall be in accordance with the standard temperature-time

curve shown by Fig. 1. The points on the curve that determine its character are:

Ambient at 0 min
1000°F(538°C) at 5 min
1300°F(704°C) at 10 min
1550°F(843°C) at 30 min
1700°F(927°C) at 60 min
1850°F(1010°C) at 120 min
2000°F(1093°C) at 240 min
2300°F(1260°C) at 480 min or over

6.2 Furnance Temperatures:

6.2.1 The temperature fixed by the curve shall be the average temperature obtained from the readings of thermocouples symmetrically disposed and distributed within the test furnace to show the temperature near all parts of the assembly. Use a minimum of three thermocouples, with not fewer than five thermocouples per 100 ft² (9.29 m²) of floor surface, and not fewer than nine thermocouples per 100 ft² (9.29 m²) of wall specimen surface.

6.2.2 Enclose the thermocouples in sealed protection tubes of such materials and dimensions that the time constant of the protected thermocouple assembly lies within the range¹ from 300 to 400 s. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 in. (300 mm). Other types of protection tubes of pyrometers may be used provided that temperature measurements obtained in accordance with Fig. 1 are within the limit of accuracy that applies for furnace temperature measurements.

6.2.3 For floors, place the junction of the thermocouples 12 in. (300 mm) away from the exposed face of the assembly. In the case of walls, place the thermocouples 6.0 in. (150 mm) away from the exposed face.

6.2.4 Read the temperature at intervals not exceeding 5 min during the first 120 min. Thereafter, the intervals may be increased to not more than 10 min.

6.2.5 The accuracy of the furnace control shall be such that the area under the temperature-time curve, obtained by averaging the

¹A typical thermocouple meeting these time-constant requirements may be fabricated by fusion-welding the twisted ends of No. 18 B and S gage (0.040 in.) (1.02 mm) Chromel-Alumel wires, mounting the leads in porcelain insulators and inserting the assembly so the thermocouple bead is 0.50 in. (13 mm) from the sealed end of a standard weight, nominal 1/2 in. iron, steel or Inconel pipe. The time constant for this and for several other thermocouple assemblies was measured in 1976. The time constant may also be calculated from knowledge of its physical and thermal properties. See Research Report RR-E-5-1001, available from ASTM Headquarters.



results from the pyrometer or thermoelectric device readings, is within 10 % of the corresponding area under the standard temperature-time curve shown in Fig. 1 for fire tests of 60 min or less duration; within 7.5 % for those over 60 min and not more than 120 min; and within 5 % for tests exceeding 120 min in duration.

6.3 *Unexposed Surface Temperatures:*

6.3.1 Make at least one measurement at each of the following locations on the unexposed surface of the test sample and floor or wall assembly as shown in Fig. 2.

6.3.2 Additional temperature measurements may be made at the discretion of the testing agency to obtain representative information of the performance of the fire stops.

6.3.3 Measure temperatures on the surface of the fire stop and assembly with thermocouples placed under flexible pads specified in Annex A2. The pads shall be held firmly against the surface; they shall fit closely about the thermocouples. The thermocouple junction shall be located under the center of the pads. The thermocouple leads under the pads shall be not heavier than No. 18 B and S gage (0.040 in.) (1.02 mm) and shall be electrically insulated with heat-resistant moisture-resistant coverings.

6.3.4 Measure temperatures of each type and size of penetrating item with at least one thermocouple located 1.0 in. (25.4 mm) from the unexposed surface of the fire-stop material. The thermocouple bead shall be held firmly against the penetrating item. The thermocouple leads shall not be heavier than No. 22 B and S gage (0.025 in.) (0.635 mm) and shall be electrically insulated with heat-resistant and moisture-resistant coverings. The pads as described above shall be held firmly against the penetrating item and shall fit closely about the thermocouples.

6.3.5 Read temperatures at intervals not exceeding 15 min until a reading exceeding 212°F (100°C) has been obtained at any one point. Thereafter, the readings may be taken more frequently at the discretion of the testing body, but the intervals need not be less than 5 min.

6.4 *Differential Pressure:*

6.4.1 Measure the pressure differential between the exposed and unexposed surfaces of the test assembly required in 9.2 at three points 0.78 in. (20 mm) from the surface and locate as follows:

6.4.1.1 *Walls*—At the center and quarter points on the vertical center line.

6.4.1.2 *Floors*—At the center and quarter points along the longitudinal center line.

6.4.2 The pressure-measuring probe tips shall be as shown in Fig. 3, manufactured from stainless steel or other suitable material.

6.4.3 Measure the pressure by means of a manometer or equivalent transducer. The manometer or transducer shall be capable of reading 0.01-in. H₂O (2.5-Pa) increments.

7. Test Sample

7.1 *Construction and Size:*

7.1.1 The construction of the test fire stops shall be of sufficient size and include all conduits, pipes, cables (jacket types, sizes, conductor types, percent fills), required supports, or other through-penetrating items so as to produce a *truly representative* fire stop for which evaluation is desired. Fire stops shall be installed and tested in each construction type for which ratings are desired.

7.1.2 Through-penetrating items shall be installed so that they extend 12 in. (300 mm) on the exposed side and 36 in. (900 mm) on the unexposed side. The extended portion of the cables on the unexposed side shall be supported in the same manner as methods employed in field installation. The individual ends of the through-penetrating items shall be covered and sealed by suitable means to prevent excessive transfer of gases through the items between the furnace and the laboratory environment.

7.1.3 The periphery of the fire stop shall not be closer than 1½ times the thickness of the test assembly or a minimum of 12 in. (300 mm) to the furnace edge, whichever is greater.¹

8. Protection and Conditioning

8.1 Prior to fire test, condition the floor or wall assembly and fire stops to provide, within a reasonable time, a moisture condition approximately representative of that likely to exist in similar construction in buildings. This moisture condition is considered as that which would be established at equilibrium resulting from drying in an ambient atmosphere of 50 % relative humidity at 73°F (23°C). However, with some assemblies and fire stops it may be difficult or impossible to achieve the equilib-

¹ The distance between fire stop periphery and furnace edge may be reduced if the testing agency demonstrates and reports that the edge effects do not affect the results.

rium moisture condition⁵ within a reasonable period of time. Therefore, floor or wall assemblies and fire stops may be tested when their dampest portion has achieved a moisture content corresponding to drying to equilibrium with air in the range from 50 to 75 % relative humidity at $73 \pm 5^\circ\text{C}$ ($23 \pm 3^\circ\text{C}$). If the assembly or fire stops dried in a heated building fail to meet these requirements after a 12-month conditioning period, or if the nature of the construction is such that drying of the assembly or fire stop interior will be prevented by hermetic sealing, these requirements may be waived, except as to attainment of the required strength as described in 9.1, and the assembly or fire stop may be tested in the condition in which it then exists.

8.2 Protect the testing equipment, sample, and assembly undergoing the fire test from any condition of wind or weather that might lead to abnormal results. The ambient air temperature at the beginning of the test shall be within the range from 50 to 90°F (10 to 32°C). The velocity of air across the unexposed surface measured just before the test begins shall not exceed 4.4 ft/s (1.3 m/s) as determined by an anemometer placed at right angles to the unexposed surface. If mechanical ventilation is employed during the test, an air stream shall not be directed across the surface of the sample.

9. Conduct of Tests

9.1 *Time of Testing*—The test sample shall not be tested until the test assembly has developed sufficient strength to retain the fire stops securely in position.

9.2 Fire Test:

9.2.1 Control the differential pressure between the exposed and unexposed surfaces of the test assembly within $\pm 20\%$ of the intended pressure during the duration of the test (excluding the first 10 min). The differential pressure employed is intended to be that pressure which will be applicable to evaluate the fire stop with respect to its field installation. A discussion concerning the selection of pressure is contained in Annex A3.

9.2.2 Continue the test until the desired evaluation period is reached or until the rating criteria of Section 10 are satisfied.

9.3 Hose Stream Test:

9.3.1 Subject a duplicate sample to a fire

exposure test for a period equal to one half of that indicated as the resistance period in the fire test, but not more than 60 min, immediately after which subject the sample to the impact, erosion, and cooling effects of a hose stream as described in Table 1 directed first at the middle and then at all parts of the exposed face, with changes in direction being made slowly.

9.3.2 The test sponsor may elect, with the advice and consent of the testing body, to have the hose stream test made on the sample subjected to the fire test and immediately following the fire test.

9.3.3 The stream shall be delivered through 2½-in. (63.5-mm) hose and discharged through a National Standard playpipe of corresponding size equipped with a 1½-in. discharge tip of the standard-taper, smooth-bore pattern without a shoulder at the orifice. The water pressure and duration of application shall be as specified in Table 1.

9.3.4 The nozzle orifice shall be 20 ft (6.1 m) from the center of the exposed surface of the test specimen if the nozzle is so located that, when directed at the center, its axis is normal to the surface of the test specimen. If otherwise located, its distance from the center shall be less than 20 ft (6.1 m) by an amount equal to 1 ft (300 mm) for each 10° of deviation from the normal.

10. Rating Criteria

10.1 F Rating:

10.1.1 A fire stop shall be considered as meeting the requirements for an F rating when it remains in the opening during the fire test and hose stream test within the following limitations.

10.1.2 The fire stops shall have withstood the fire test for the rating period without permitting the passage of flame through openings, or the occurrence of flaming on any element of the unexposed side of the fire stops.

10.1.3 During the hose stream test, the fire stop shall not develop any opening that would

⁵ A method for determining the relative humidity within a hardened concrete specimen with electric sensing elements is described in Appendix I of a paper by Carl A. Menzel, "A Method for Determining the Moisture Condition of Hardened Concrete in Terms of Relative Humidity," *Proceedings, Am. Soc. Testing Mats.*, Vol 55, 1955, p. 1083. A similar procedure with electric relative humidity within fire test assemblies and fire stops made with other materials.

permit a projection of water from the stream beyond the unexposed side.

10.2 *T* Rating:

10.2.1 A fire stop shall be considered as meeting the requirements for the *T* rating when it remains in the opening during the fire test and hose stream test within the following limitations:

10.2.1.1 The transmission of heat through the fire stops during the rating period shall not have been such as to raise the temperature of any thermocouple on the unexposed surface of the fire stop or on any penetrating item more than 325°F (163°C) above its initial temperature. Also, the fire stops shall have withstood the fire test during the rating period without permitting the passage of flame through openings, or the occurrence of flaming on any element of the unexposed side of the fire stops.

10.2.1.2 During the hose stream test, the fire stop shall not develop any opening that would permit a projection of water from the stream beyond the unexposed side.

11. Report

11.1 Results shall be reported in accordance with the performance in the tests prescribed in this method. They shall be expressed in time periods of resistance to passage of flame to the nearest integral minute. Reports shall include the following:

11.1.1 Description of the assembly, materials, and penetrating items of the test fire stop shall be identified and described. Drawings depicting geometry, exact size (length, width, thickness), and location of fire stops within the test assembly shall be recorded.

11.1.2 The relative humidities of the test assembly and fire stop materials, if applicable, shall be recorded.

11.1.3 The furnace and the unexposed side temperatures shall be recorded for the duration of the standard fire test.

11.1.4 The *F* and *T* ratings for each fire stop shall be reported in the time period of resistance.

11.1.5 The measurement of differential pressure between the exposed and unexposed test

assembly surfaces shall be recorded during the fire test and the basis for the chosen pressure shall be stated.

11.1.6 Observations of significant details of the behavior of the fire stops during the test and after the furnace fire is extinguished shall be recorded. These shall include cracks, deformation, flaming, and smoke issuance. Also, these include continued burning within the fire stop after termination of the fire test.

11.2 When the indicated, fire stop rating period is 60 min or over, a correction shall be applied for variation of the furnace exposure from the prescribed, where it will affect the rating, by multiplying the indicated period by two thirds of the difference in area between the curve of average furnace temperature and the standard curve for the first three fourths of the period and dividing the product by the area between the standard curve above a base line of 68°F (20°C) for the same part of the indicated period, the latter area increased by 54°F h or 30°C·h (3240°F·min or 1800°C·min), to compensate for the thermal lag of the furnace thermocouples during the first part of the test. For fire exposure in the test higher than standard, the indicated rating period shall be increased by the amount of the correction and be similarly decreased for fire exposure below surface. The correction can be expressed as follows:

$$C = \frac{2I(A - A_s)}{3(A_s + L)}$$

where:

C = correction in the same units as *I*.

I = indicated fire-resistance period.

A = area under the curve of indicated average furnace temperature for the first three fourths of the indicated period.

A_s = area under the standard furnace curve for the same part of the indicated period, and

L = lag correction in the same units as *A* and *A_s*, (54°F·h or 30°C·h; 3240°F·min or 1782°C·min).

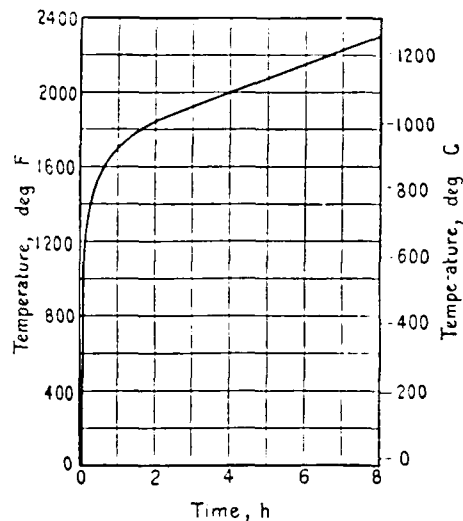
12. Precision and Accuracy

12.1 The precision and accuracy of this method have not been determined.

TABLE 1 Pressure and Duration—Hose Stream Test⁴

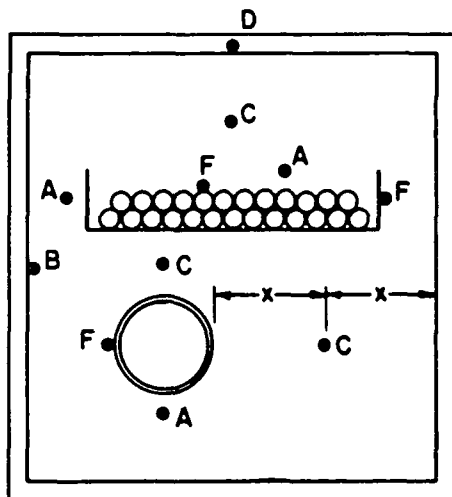
| Resistance Period | Water Pressure at Base of Nozzle, psi (kPa) | Duration of Application, Seconds Per ft ² (m ²) of Exposed Area |
|---------------------------------------|---|--|
| 240 min and over if less than 480 min | 45(310) | 3.0(32) |
| 120 min and over if less than 240 min | 30(210) | 1.5(16) |
| 90 min and over if less than 120 min | 30(210) | 0.90(10) |
| 60 min and over if less than 90 min | 30(210) | 0.60(6) |
| Less than 60 min if desired | 30(210) | 0.60(6) |

⁴ When a single fire stop is tested, calculation of the area to be exposed to the hose stream may include more than the outside dimensions of the fire stop if the hose stream uniformly traverses that area. Where multiple test fire stops are tested in the same wall or floor assembly, the rectangular area encompassing all of the fire stops shall be considered as the exposed area since the hose stream must traverse this calculated area during its application.

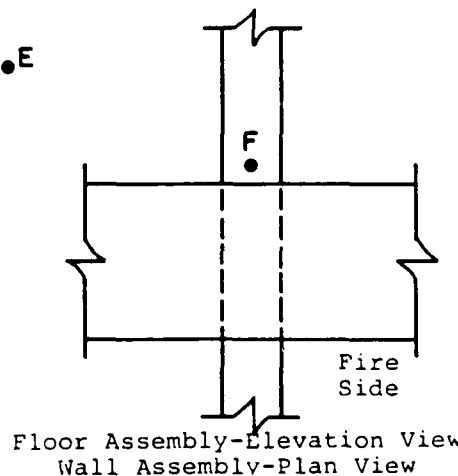


NOTE—For a closer definition of the temperature-time curve, see Annex A1.

FIG. 1 Temperature-Time Curve



Floor Assembly-Plan View
Wall Assembly-Elevation View



Floor Assembly-Elevation View
Wall Assembly-Plan View

Legend:

- A — At a point on the surface of the fire stop 1 in. (25 mm) from one through-penetrating item for each type of penetrating item employed in the field of the fire stop. If the grouping of penetrating items through the test sample prohibits placement of the thermocouple pad, the thermocouple shall not be required.
- B — At a point on the fire stop surface at the periphery of the fire stop.
- C — At a minimum of three points on the fire stop surface approximately equidistant from a penetrating item or group of penetrating items in the field of the fire stop and the periphery.
- D — At one point on any frame that is installed about the perimeter of the opening.
- E — At one point on the unexposed surface of the wall or floor that is a minimum of 12 in. (305 mm) from any opening.
- F — At one point on each type of through-penetrating item.

FIG. 2 Temperature Measurement Locations

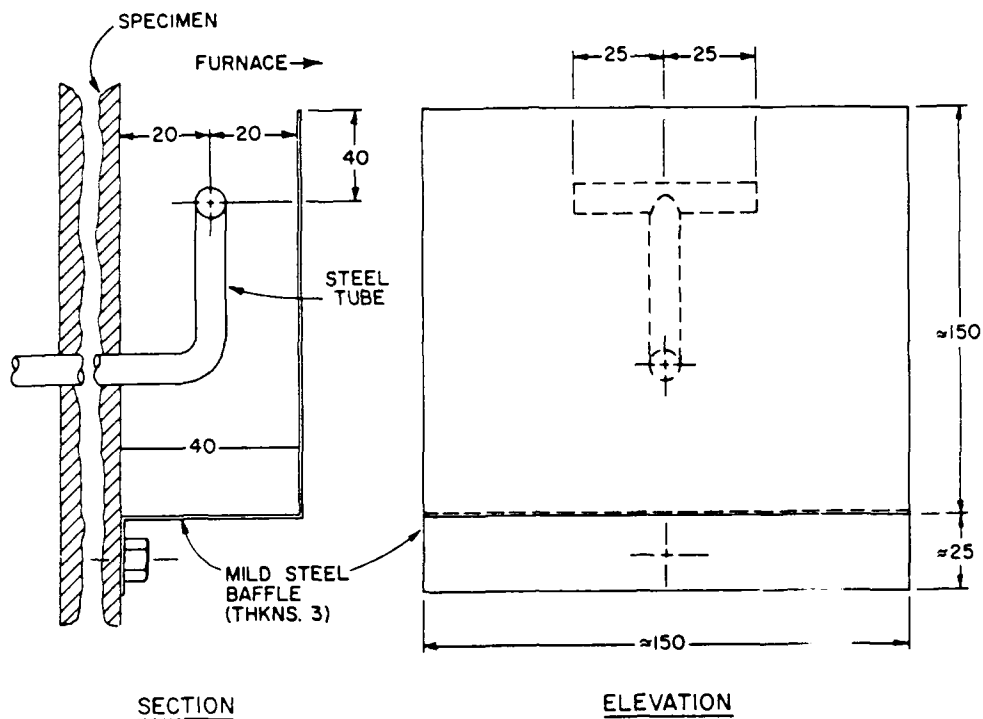


FIG. 3 Static Pressure-Measuring Device Dimensions in Millimetres

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

ANNEXES

A1. STANDARD TEMPERATURE-TIME CURVE FOR CONTROL OF FIRE TESTS

| Time h min | Temperature, °F | Area Above 68°F Base | | Temperature, °C | Area Above 20°C Base | |
|---------------|--------------------|----------------------|--------|--------------------|----------------------|-------|
| | | °F-min | °F-h | | °C-min | °C-h |
| 0 00 | 68 | 00 | 0 | 20 | 00 | 0 |
| 0 05 | 1 000 | 2 330 | 39 | 538 | 1 290 | 22 |
| 0 10 | 1 300 | 7 740 | 129 | 704 | 4 300 | 72 |
| 0 15 | 1 399 | 14 150 | 236 | 760 | 7 860 | 131 |
| 0 20 | 1 462 | 20 970 | 350 | 795 | 11 650 | 194 |
| 0 25 | 1 510 | 28 050 | 468 | 821 | 15 590 | 260 |
| 0 30 | 1 550 | 35 360 | 589 | 843 | 19 650 | 328 |
| 0 35 | 1 584 | 42 860 | 714 | 862 | 23 810 | 397 |
| 0 40 | 1 613 | 50 510 | 842 | 878 | 28 060 | 468 |
| 0 45 | 1 638 | 58 300 | 971 | 892 | 32 390 | 540 |
| 0 50 | 1 661 | 66 200 | 1 103 | 905 | 36 780 | 613 |
| 0 55 | 1 681 | 74 220 | 1 237 | 916 | 41 230 | 687 |
| 1 00 | 1 700 | 82 330 | 1 372 | 927 | 45 740 | 762 |
| 1 05 | 1 718 | 90 540 | 1 509 | 937 | 50 300 | 838 |
| 1 10 | 1 735 | 98 830 | 1 647 | 946 | 54 910 | 915 |
| 1 15 | 1 750 | 107 200 | 1 787 | 955 | 59 560 | 993 |
| 1 20 | 1 765 | 115 650 | 1 928 | 963 | 64 250 | 1 071 |
| 1 25 | 1 779 | 124 180 | 2 070 | 971 | 68 990 | 1 150 |
| 1 30 | 1 792 | 132 760 | 2 213 | 978 | 73 760 | 1 229 |
| 1 35 | 1 804 | 141 420 | 2 357 | 985 | 78 560 | 1 309 |
| 1 40 | 1 815 | 150 120 | 2 502 | 991 | 83 400 | 1 390 |
| 1 45 | 1 826 | 158 890 | 2 648 | 996 | 88 280 | 1 471 |
| 1 50 | 1 835 | 167 700 | 2 795 | 1 001 | 93 170 | 1 553 |
| 1 55 | 1 843 | 176 550 | 2 942 | 1 006 | 98 080 | 1 635 |
| 2 00 | 1 850 | 185 440 | 3 091 | 1 010 | 103 020 | 1 717 |
| 2 10 | 1 862 | 203 330 | 3 389 | 1 017 | 112 960 | 1 882 |
| 2 20 | 1 875 | 221 330 | 3 689 | 1 024 | 122 960 | 2 049 |
| 2 30 | 1 888 | 239 470 | 3 991 | 1 031 | 133 040 | 2 217 |
| 2 40 | 1 900 | 257 720 | 4 295 | 1 038 | 143 180 | 2 386 |
| 2 50 | 1 912 | 276 110 | 4 602 | 1 045 | 153 390 | 2 556 |
| 3 00 | 1 925 | 294 610 | 4 910 | 1 052 | 163 670 | 2 728 |
| 3 10 | 1 938 | 313 250 | 5 221 | 1 059 | 174 030 | 2 900 |
| 3 20 | 1 950 | 332 000 | 5 533 | 1 066 | 184 450 | 3 074 |
| 3 30 | 1 962 | 350 890 | 5 848 | 1 072 | 194 940 | 3 249 |
| 3 40 | 1 975 | 369 890 | 6 165 | 1 079 | 205 500 | 3 425 |
| 3 50 | 1 988 | 389 030 | 6 484 | 1 086 | 216 130 | 3 602 |
| 4 00 | 2 000 | 408 280 | 6 805 | 1 093 | 226 820 | 3 780 |
| 4 10 | 2 012 | 427 670 | 7 128 | 1 100 | 237 590 | 3 960 |
| 4 20 | 2 025 | 447 180 | 7 453 | 1 107 | 248 430 | 4 140 |
| 4 30 | 2 038 | 466 810 | 7 780 | 1 114 | 259 340 | 4 322 |
| 4 40 | 2 050 | 486 560 | 8 110 | 1 121 | 270 310 | 4 505 |
| 4 50 | 2 062 | 506 450 | 8 441 | 1 128 | 281 360 | 4 689 |
| 5 00 | 2 075 | 526 450 | 8 774 | 1 135 | 292 470 | 4 874 |
| 5 10 | 2 088 | 546 580 | 9 110 | 1 142 | 303 660 | 5 061 |
| 5 20 | 2 100 | 566 840 | 9 447 | 1 149 | 314 910 | 5 248 |
| 5 30 | 2 112 | 587 220 | 9 787 | 1 156 | 326 240 | 5 437 |
| 5 40 | 2 125 | 607 730 | 10 129 | 1 163 | 337 630 | 5 627 |
| 5 50 | 2 138 | 628 360 | 10 473 | 1 170 | 349 090 | 5 818 |
| 6 00 | 2 150 | 649 120 | 10 819 | 1 177 | 360 620 | 6 010 |
| 6 10 | 2 162 | 670 000 | 11 167 | 1 184 | 372 230 | 6 204 |
| 6 20 | 2 175 | 691 010 | 11 517 | 1 191 | 383 900 | 6 398 |
| 6 30 | 2 188 | 712 140 | 11 869 | 1 198 | 395 640 | 6 594 |

A2. REQUIREMENTS FOR THERMOCOUPLE PADS

A2.1 The pads used in measurements of temperature of unexposed surfaces of specimens shall be of suitable inorganic material and shall exhibit the following properties:

A2.1.1 *Length and Width*— 2.00 ± 0.04 in. (50.8 ± 1 mm).

A2.1.2 *Thickness*— 0.40 ± 0.05 in. (10 ± 1 mm).

A2.1.3 *Density*— 31.2 ± 0.6 lb/ft³ (500 ± 10 kg/m³).

A2.1.4 *Thermal Conductivity at 150°F*— 0.380 ± 0.027 Btu·in./h·ft²·°F (0.055 ± 0.003 W/m·K).

A2.2 The pads shall be sufficiently soft so that without breaking, they may be shaped to contact over the whole surface against which they are placed.

A3. DIFFERENTIAL PRESSURE SELECTION

A3.1 The differential pressure employed in testing should be determined by either (1) code requirements, (2) the design pressure that may occur in the

type of installation for which the test is proposed, (3) the test sponsor, or (4) other circumstances.

APPENDIX

XI. DISCUSSION OF SEVERAL ITEMS OF THE METHOD

X1.1 Introduction

X1.1.1 In writing this standard, various comments and engineering points of view were considered. The method was written to reflect the broadest possible consensus of these comments.

X1.1.2 This appendix provides a brief discussion of several significant items that were considered. It is intended that the basis for the items included in the method as well as conflicting points of view, be presented in this discussion.

X1.2 Applicability

X1.2.1 This method is applicable to through-penetration fire stops of various materials and construction. These fire stops are intended for use in openings in fire resistive walls and floors.

X1.2.2 This method does not apply to termination devices intended to provide electrical, communication, or other circuitry at the surface of the assembly, and which are evaluated as an integral part of an assembly in accordance with Methods E 119.

X1.3 Criteria

X1.3.1 *General*—This fire method for fire stops is intended to be concerned with evaluating protection provided for openings created in walls or floors which otherwise have a fire resistance rating established in accordance with Method E 119. Presently fire doors and windows, which are similar items, are evaluated by other ASTM standards. Accordingly, the objective of this method is to assure that the use of such fire stops would not jeopardize the required fire resistance performance of the wall or floor assembly. The rating criteria are accordingly predicated on those conditions relevant to ratings of walls and floors by Method E 119, modified to the extent necessary to take cognizance of the special conditions represented by the occurrence of the fire stops including the penetrating items. In Method E 119, conditions of acceptance include (1) passage of flame and hot gases, (2) unex-

posed surface temperature rise, (3) ignition of cotton waste, and (4) hose stream.

X1.3.2 *Passage of Flame and Hot Gases and Ignition of Cotton Waste*—In Method E 119 one criterion of acceptance of a floor-ceiling or wall is that the assembly shall have withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste. The object of this criterion is to minimize the potential for igniting combustible material that might be placed in contact with the unexposed surface. In this method, the use of cotton waste is excluded and the judgment shall be based only upon visual observation and surface temperatures.

X1.3.3 In Method E 119, visual observation of the passage of flames and hot gases is supplemented with the use of cotton waste. The cotton waste serves as an additional indicator where visual observations are insufficient to determine whether passage of hot gases is occurring. In this method the cotton waste criterion was excluded for the following reasons: (1) the through-penetrating items of a fire stop which continue beyond the wall or floor surface often constitute the combustibles at the unexposed surface, while at the same time minimize the opportunity for other combustibles to come in contact with the wall or floor at the vicinity of the penetration and (2) the through-penetrating items may be of a nature that they inhibit placement of the cotton waste on the protection material surface, while at the same time often being of sufficient temperature that contact with the cotton waste would ignite the cotton waste, thus giving a false indication of fire stop surface ignition.

X1.3.4 *Unexposed Surface Temperatures*—It has been argued that temperatures on the unexposed surface should not be considered in determining the performance of the fire stops, since the fire stops will be installed in such places where they will not be in contact with wood, carpeting, plastic, or other such materials which may ignite at relatively low temperatures. It is further argued a temperature limitation should not be imposed on frames about the opening



of fire stop devices or systems since they represent a direct path for heat to flow through to the unexposed surface.

X1.3.5 While these arguments may be valid for some installations, it will be true that the fire stop devices will also be used in areas where they will come in contact with wood, dust, carpeting, paint, wall coverings, or other such materials.

X1.3.6 Further, there are cases where rigorous regulations prohibit combustibles, other than the material that passes through the wall or floor, from the area in which the fire stops are located. However, the record clearly establishes that combustible materials such as dust accumulation, workman's clothing items, miscellaneous building and repair items may well be found in such locations.

X1.3.7 It has been argued that the use of temperature limitation as described in Method E 119 must be retained if the overall character of the fire-resistance rating is to be retained.

X1.3.8 In order to satisfy both positions this method provides two ratings: a *T* rating incorporating temperature and flame limitation, and an *F* rating predicated only on observation of passage of flame or hot gases.

X1.3.9 The *F* rating is based upon observation of passage of flame. The *T* rating is based upon passage of flame and a maximum individual temperature limitation of 325°F (181°C) above ambient. Therefore, depending upon the construction, the authority having jurisdiction may choose the rating that is most appropriate to fulfill the particular needs of the building.

X1.3.10 Placement of thermocouples as specified by the method is predicated on obtaining temperatures representative of the various fire-stop items, and the difference in heat transmission through the fire-stop material at various locations.

X1.3.11 A location of approximately 1.0 in. (25 mm) from a penetrating item on the unexposed surface of the fire stop would represent a hot point on fire-stop surface. The distance of 1.0 in. (25 mm) was obtained since one size of standard thermocouple pads is 2.0 by 2.0 in. (50 by 50 mm), and the thermocouple junctions shall be at the center of the pad. This fixes 1.0 in. (25 mm) as the closest permitted spacing from penetrating items.

X1.3.12 A location at a point on the surface at the periphery of the fire-stop material, and at a point approximately equidistant from penetrating items in the field of the fire stop and the periphery would obtain temperature information helpful in evaluating the thermal transmission through the fire stop.

X1.3.13 Also, temperatures of any frame about the opening and the temperatures of penetrating items (that is, cable conductor, conduit) shall be recorded in evaluating the thermal transmission performance of the fire stop.

X1.3.14 The method indicates that the use of additional thermocouples may be required as determined for individual fire stops.

X1.3.15 *Hose Stream Test*—Passage of the hose stream test was included as an acceptance criterion since it is an indicator of the integrity of the fire stop during fire exposure and the overall reliability of the material to perform its intended function. The hose stream test method as outlined in Method E 119 is considered as applicable to the fire stops.

X1.3.16 Not to conduct a hose stream test without applying any design live load to the test assemblies, would be fire testing the assemblies while ignoring their integrity. It is important that an indication of the integrity of performance be obtained for the fire stops. *Failure of the integrity of the fire stops* would aid the spread of fire by causing passages for the flames and hot gases.

X1.3.17 However, it was argued that conducting the hose stream test may be difficult to perform at various testing facilities without significant modifications to equipment.

X1.3.18 It was proposed that the hose stream test be included as an option only. Also, it was argued that different hose streams (pressure, spray, durations) be included as an option.

X1.3.19 Although the hose stream tests provide a measure of the structural performance of the fire stop material, it should not be construed as a measure of the load carrying ability of the fire stop tested.

X1.3.20 Also, the hose stream test is not intended to evaluate the structural performance of the floor or wall after the inclusion of the various fire stops.

X1.4 Test Sample

X1.4.1 The cables, conduits, pipes and other penetrating items used in the fire stops shall be representative of the fire stop for which evaluation is desired. It is intended that the data and information provided by the testing of the fire stops with various penetrating items would be used to determine acceptability of a specific fire stop in the construction.

X1.4.2 Extension of cables, conduits, and pipes 3 ft (0.9 m) beyond the unexposed surface, as shown by previous testing, satisfactorily represents continuous cables and conduit as would be encountered in the field condition.

X1.5 Conduct of Tests

X1.5.1 The method specifies that pressure in the furnace chamber with respect to the unexposed surface shall be that pressure which will be applicable to evaluate the fire stop with respect to its field installation. This pressure shall be determined by a specific code requirement, by the special design pressures in the building in which the fire stop is to be installed, or by the test sponsor requesting a special environment to evaluate the fire stop sample.



APPENDIX C

UNDERWRITERS LABORATORIES INC.

333 PFINGSTEN ROAD NORTHBROOK, ILLINOIS 60062

an independent, not-for-profit organization testing for public safety

cc: File USNC142
NFF - USCG (2)
NFF - Mark Izydorek
NFF - Gerald Palikij
NFF - Sec. B Aide

UNDERWRITERS LABORATORIES INC.

REPORT

on

FIRE TESTS CONDUCTED UNDER PURCHASE ORDER
NO. DTCG50-86-P-00737

by

Mark Izydorek

for

United States Department of Transportation
United States Coast Guard
Research and Development Center
Groton, CT

Representative: Mr. David E. Beene, Jr.
Fire Safety Specialist

August 15, 1986

File USNC142
Project 86NK8673

NOTE: ALL THERMOCOUPLE READINGS IN APPENDIX C
ARE RECORDED IN DEGREES FAHRENHEIT.

Look For The  Listing or Classification Mark On The Product

N O T I C E

This Report was prepared as an account of work sponsored by the United States Government. Neither the United States Government nor Underwriters Laboratories Inc. nor any of their employees nor any of their contractors, subcontractors, or their employees make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or processes disclosed, or represents that its use would not infringe on privately owned rights. This Report may not be used in any way to infer or to indicate acceptability by Underwriters Laboratories Inc. for any product or system.

A B S T R A C T

Tests were conducted on eight Class A-0 deck assemblies, twenty-seven Class A-60 deck assemblies and three assemblies with insulation installed by way of the transit only. Each test sample was a 36 by 36 in. by 3/16 in. thick steel plate with a penetrating item. Eighteen penetrating items were submitted. Each penetrating item was installed through a Class A-0 deck assembly and/or through a Class A-60 deck assembly. The penetrating items included steel pipe, copper pipe, PVC pipe, steel duct and electrical cables.

All tests were conducted in accordance with the Standard, Fire Tests of Through-Penetration Firestops, UL 1479 (ASTM E814). The thirty-eight samples were exposed to a 1 hour furnace fire that reached a temperature of 1000°F at 5 min, 1550°F at 30 min, and 1700°F at 60 min. Within 5 min after the fire exposure, each of the thirty-eight samples was subjected to a water stream of 30 psi for a 13.5 second duration.

During the tests, measurements and observations were made of the passage of flame and water through the deck assemblies, the temperature of assemblies, the temperature of the furnace and the pressure of the water stream. The pressure conditions within the furnace were measured during six of the thirty-eight tests as requested by the USCG. Photographic and video records of the thirty-eight tests were obtained.

F O R E W O R D

This is a final report of an investigation conducted under Purchase Order No. DTCG50-86-P-00737 issued by the United States Department of Transportation, United States Coast Guard for the second phase of their R & D Project No. 2284.

The test work was conducted during the time period of June, 1986 to July, 1986.


Respectfully submitted

UNDERWRITERS LABORATORIES INC.



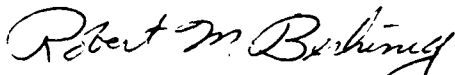
MARK IZYDOREK (Ext. 3352)
Engineering Assistant
Fire Protection Department

Reviewed by:



GERALD D. PALIKIJ (Ext. 2758)
Senior Engineering Assistant
Fire Protection Department

Reviewed and approved by:



ROBERT M. BERHINIG (Ext. 2292)
Associate Managing Engineer
Fire Protection Department

I N T R O D U C T I O N

The tests were conducted to provide data to the United States Coast Guard (USCG) and the Canadian Coast Guard (CCG) in the second phase of their joint study of firestop systems (R & D Project No. 2284) used to prevent the passage of flame and hot gases at penetrating items through Class A-0 and through Class A-60 deck assemblies.

Eighteen combinations of firestop systems and penetrating items were tested. The thirty-eight samples for the second phase of USCG and CCG R & D Project No. 2284 were identified by the USCG.

The identification numbers represent the sample constructions that were tested in the first phase of the USCG and CCG joint study under Project 84NK8504, File USNC142 (Report dated October 19, 1984).

| <u>Identification No.</u> <u>(Number Of Tests)</u> | <u>Sample Description</u> |
|---|---|
| D-3 (1) | Original D-3, but retested with A-60 insulation on the unexposed side. |
| D-4 (2) | Original D-4, but retested with A-60 insulation on exposed side covering flange and A-60 insulation on unexposed side also covering flange. |
| D-5 (1) | Original D-5, but retested with A-60 insulation on the unexposed side. |
| D-6 (1) | Original D-6, but retested with A-60 insulation on the unexposed side. |
| D-9 (1) | Original D-9, but retested with A-60 insulation on the unexposed side. |
| D-10 (3) | Redesign of D-10 with longer (15 in.) steel spigot. Tested with A-60 insulation on both the exposed and unexposed sides, also tested without insulation as A-0. |
| D-11 (1) | Original D-11, but retested A-60 insulation on unexposed side. |

Identification No.
(Number Of Tests)Sample Description

| | |
|----------|---|
| D-14 (3) | Redesign of D-14 with longer (15 in.) spigot. Tested with A-60 insulation on both the exposed and unexposed sides, also tested without insulation as A-0. |
| D-15 (1) | Original D-15, but retested with A-60 insulation on unexposed side. |
| D-16 (1) | Original D-16, but retested with A-60 insulation on unexposed side. |
| D-17 (3) | Redesign of D-17. Tested with A-60 insulation on both the exposed and unexposed sides, also tested without insulation as A-0. |
| D-19 (4) | Original D-19, but retested with A-60 insulation on the unexposed side, also tested with 6 in. of insulation on both the exposed and unexposed sides by way of transit only. One additional sample was tested with 3 in. of insulation on each side by way of the transit only. |
| D-21 (1) | Original D-21, but retested with A-60 insulation on the unexposed side. |
| D-22 (3) | New design, tested with A-60 insulation on both the exposed and unexposed sides, also tested without insulation as A-0. |
| D-23 (3) | Redesign of D-20 with longer spigot. Tested with A-60 insulation on both the exposed and unexposed sides, also tested without insulation as A-0. |
| D-24 (3) | New design, tested with A-60 insulation on both the exposed and unexposed sides, also tested without insulation as A-0. |
| D-25 (3) | Redesign of D-17, tested with A-60 insulation in both the exposed and unexposed sides, also tested without insulation as A-0. |
| D-26 (3) | New design, tested with A-60 insulation on both the exposed and unexposed sides, also tested without insulation as A-0. |

Construction drawings of each test sample are shown in each of their respective "Test Records." A suffix was added to each sample identification number identifying its construction, they are as follows:

- /A0 - Without insulation
- /A60E - Insulation installed on the exposed surface
- /A60U - Insulation installed on the unexposed surface

The original construction drawings sent to UL by the CCG are contained in this Report. Copies of this Report contain copies of the construction drawings in which some clarity was lost during the reproduction process.

All tests were conducted in accordance with the Standard, Fire Tests of Through-Penetration Firestops, UL 1479. This Standard is used to determine hourly ratings for firestop systems surrounding items penetrating through hourly rated fire resistive horizontal and vertical assemblies.

UL's small-scale horizontal furnace was used for all fire tests. This furnace has a horizontal opening of 31.5 by 31.5 in. with a depth of 32.5 in. A positive pressure differential was maintained between the furnace chamber and the laboratory.

The data package obtained during each test consisted of temperature measurements, photographic and video records, and visual observations. Temperatures were recorded at 4 min intervals at various locations on each test sample. Photographs of the samples were obtained before the fire tests, at 5 min intervals during the fire tests, after the fire tests, during the water stream tests and after each water stream test. A photographic sign board was pictured in each photograph providing the following information: The sample designation or identification number, UL's test number, the test date and a Reference Letter "P," "T," "A" or "S." "P" referenced pre-test photographs, "T" referenced photographs during the fire test, "A" referenced after fire test photographs and "S" referenced after hose stream photographs. A clock was present in each photograph during the fire test showing the test duration. The appearance of each sample was observed during each fire test and after each water stream test. A "Composite" video was recorded for two samples (D10/A60U and D23/A60U) illustrating various stages of the test program. Pressure measurements within the test furnace were recorded for six tests.

The USCG and CCG selected and designed the penetrating items and firestop systems tested. Most of the thirty-eight samples were delivered to UL with the penetrating items and firestop systems installed. Installing OAKUM and RTV sealants on approximately nine samples was done by members of UL's technical staff and representatives of the USCG and CCG at Underwriters Laboratories. The rockwool insulation was installed at UL by members of UL's technical staff.

The penetrating items included various combinations of steel pipe, copper pipe, PVC pipe, steel air ducts, and electrical cables. The firestop systems included steel plate, bronze plate and proprietary fire resistive sealants and devices.

C O N S T R U C T I O N O F T E S T A S S E M B L I E S

The construction details of the test assemblies were designed by the USCG and CCG. The samples were received at UL with the various penetrating items attached to the 36 in. by 36 in. by 3/16 in. thick steel plates. All samples were representative of an A-0 construction when received at Underwriters Laboratories Inc.

For samples representative of an A-60 construction, members of UL's technical staff secured rockwool batts to either the fire side, the nonfire side or both sides of the steel plates and penetrating items. The rockwool batts were 75 mm thick and bore a label containing the following information:

MA. Firebatts
110 Kg/m³
900 x 600 x 75 mm
4 pieces
Rockwool

The 75 mm thick batts were secured to the steel plates and penetrating items. To secure the batts to the steel plates, 0.093 in. diameter steel pins were welded to the plates at a horizontal and vertical spacing designated by the USCG. The batts were impaled onto the pins and a single layer of hexagonal wire netting was wrapped around the rockwool batts. The batts and netting were secured in place by means of clinch shields. The netting was formed by 0.041 in. diameter steel wire twisted into 2 in. hexagons. The excess length of the steel pins was then cut off. Steel pins were also attached to some of the steel penetrating items, and the batts and netting were affixed to the penetrating items in the same manner.

T E S T R E C O R D - G E N E R A LFIRE EXPOSURE TEST:

The fire tests were conducted with the furnace temperatures controlled in accordance with the requirements of Standard, "Through-Penetration Firestops," UL 1479 (ASTM E814).

METHOD

The assemblies were tested on a horizontal furnace having a 31.5 in. by 31.5 in. opening. Details of the furnace are shown on ILL. 1. The furnace temperatures, measured 12 in. below the exposed surface of the test specimen, were adjusted to follow the Standard Time-Temperature Curve as specified in the Standard, UL 1479. These temperatures were measured by means of two thermocouples diametrically located at the quarter points.

Type K, No. 24 gauge chromel-alumel thermocouples were used for all temperature measurements on the deck assemblies. The thermocouples were covered with 2 in. by 2 in. by 7/16 in. thick dry ceramic fiber pads. The location of the thermocouples are as shown in ILLS. following each "Test Record."

The pressure differential between the furnace and the laboratory was measured with a probe connected to a manometer. During the tests of Samples D3/A60U, D5/A60U, D17/A60E, D19/A60-9U, D22/A60U and D26/A60U, the pressure probe was placed 0.25 in. below the exposed surface and was located as shown on ILL. 2. The furnace operation during these six fire tests was typical of the furnace operation for all thirty-eight fire tests.

RESULTS

Throughout the fire tests, observations were made of the character of the fire and its control, the conditions of the exposed and unexposed surfaces, and all developments pertaining to the performance of the penetrating items with special reference to integrity of the assembly and flame passage through the assembly. All observations are reported in each "Test Record."

The temperature measured on the test assemblies during each test are shown on ILLS. following each "Test Record."

The pressure measurements recorded during the tests of Samples D3/A60U, D5/A60U, D17/A60E, D19/A60-9U, D22/A60U and D26/A60U are reported in each of their respective "Test Records."

HOSE STREAM TEST:

SAMPLE

The hose (water) stream was applied to the exposed surface of the deck assembly. Immediately following the fire exposure test, the sample was removed from the furnace and placed in a steel support rack which pivoted the sample approximately 90° such that the exposed and unexposed surfaces of the sample, as fire tested, were orientated vertically like a wall assembly. The hose stream test commenced approximately 4 min after the furnace fire was extinguished.

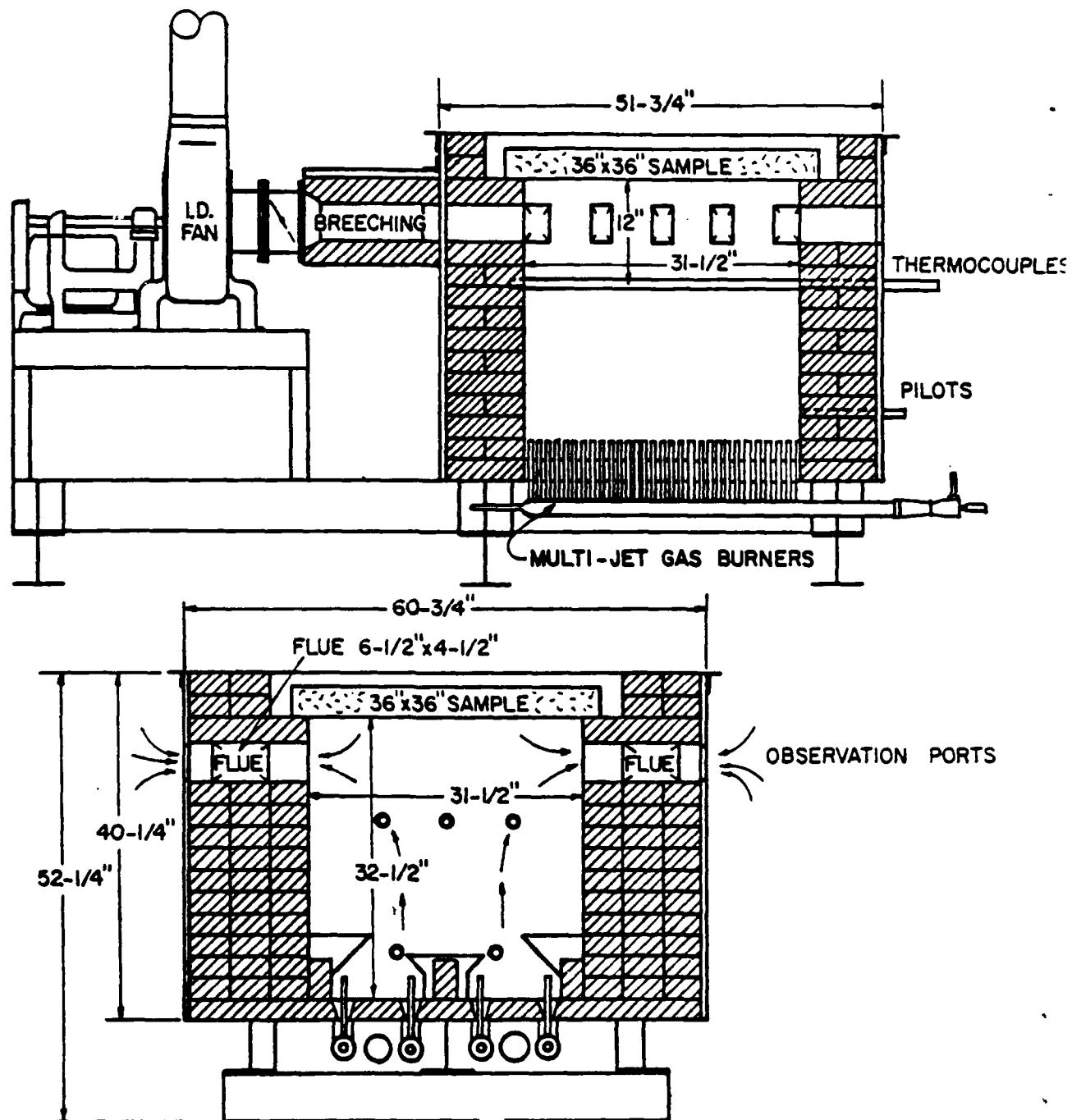
METHOD

The hose (water) stream test was conducted in accordance with the Standard, "Through-Penetration Firestops," UL 1479 (ASTM E814) assuming the samples were exposed to a 2 h fire test. Therefore, the assemblies were subjected to the action of a 30 psi water stream applied for a duration of 1.5 s/ft² of exposed area. The water stream was applied with a 1-1/8 in. diameter nozzle at a perpendicular distance of 20 ft from the center of the test assembly. The water stream was applied to the 9 ft² samples for 13.5 seconds and traversed the deck assembly and penetrating item. The hose stream exposure was of the same pressure and the same duration as applied to samples tested during Phase I of the study.

RESULTS

The results of each hose stream test are noted in each sample's "Test Record."

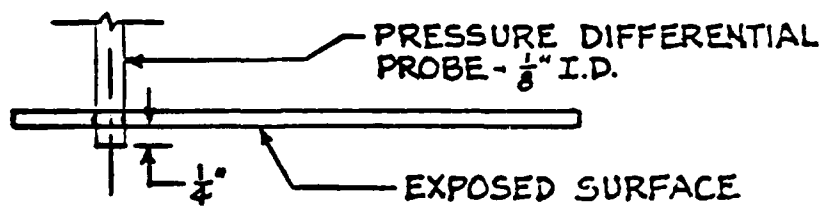
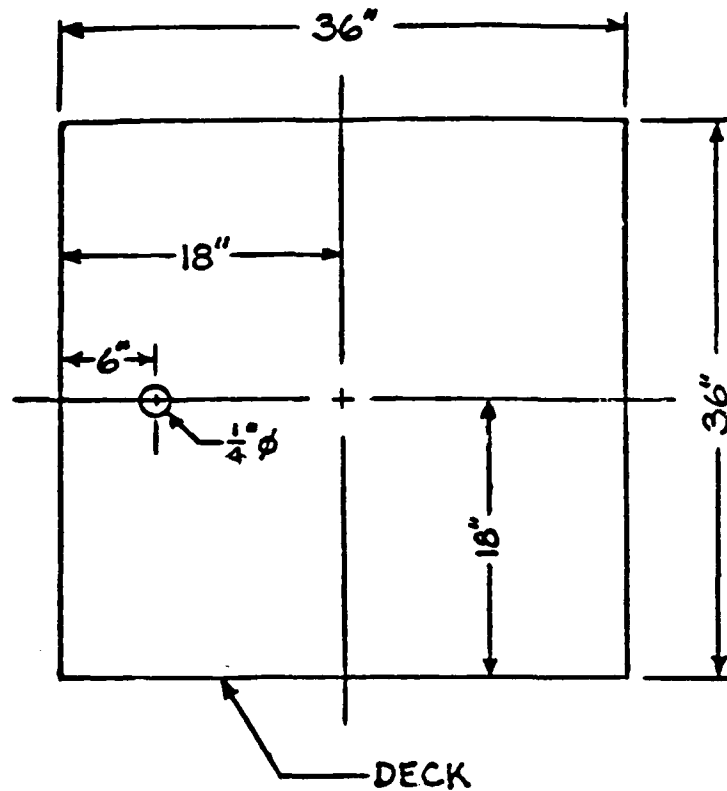
SMALL SCALE HORIZONTAL EXPOSURE FURNACE



USNC 142
ILL. 1

Samples

D3/A60U
D5/A60U
D17/A60E
D19/A60-9U
D22/A60U
D26/A60U



PRESSURE DIFFERENTIAL PROBE
LOCATIONS

USNC 142
ILL. 2

T E S T R E C O R D D3/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D3/A60U and as shown in ILL. 3.

The fire and hose stream tests were conducted on June 24, 1986 and identified by UL as Test No. 32.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 10 | The steel plate bowed and twisted along with the insulation. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Note: When removing the test assembly from the furnace, the 3 in. diameter copper pipe on the exposed side, below the bronze flange, collapsed.

Temperature of the Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 4.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 5 through 5B.

Pressure Record - The pressure within the test furnace ranged from +0.005 in./H₂O to +0.01 in./H₂O (+1.24 Pa to +2.5 Pa), throughout the duration of the fire endurance test.

HOSE STREAM TEST:

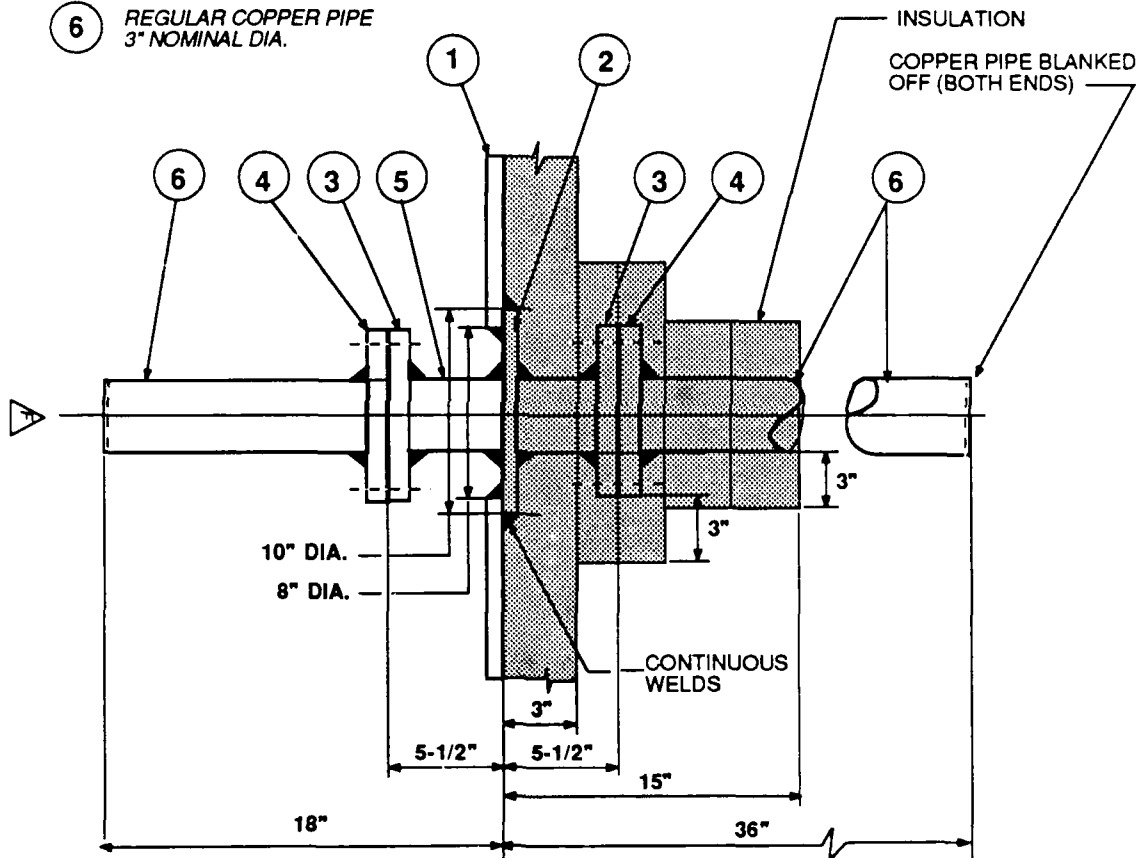
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D3/A60U
UL TEST NO. 32

- ① STEEL PLATE, 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② STEEL PLATE COLLAR 10" DIA. X 3/16" THICK.
ASTM A-53, GRADE A OR B.
- ③ 150 LBS STEEL FLANGE
3" NOMINAL DIA. PIPE SIZE.
- ④ 150 LBS BRONZE FLANGE
3" NOMINAL DIA. PIPE SIZE.
- ⑤ SEAMLESS STEEL PIPE,
3" NOMINAL DIA. PIPE SIZE,
SCHEDULE 40.
- ⑥ REGULAR COPPER PIPE
3" NOMINAL DIA.



TEST SAMPLE NO. D-3A
COPPER PIPE WITH
STEEL SPIGOT
(R&DC GRAPHIC 1)

USNC 142
ILL. 3

SAMPLE D3A60U
TEST DATE JUNE 24, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On penetrant, 4-1/2 in. above steel plate. |
| 2 | On penetrant, 6-1/2 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, 18 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | On steel plate insulation, at interface of penetrant insulation. |
| 7 | On steel plate insulation seam, at interface of penetrant insulation. |
| 8 | On steel plate insulation, 1 in. from penetrant insulation. |
| 9 | On steel plate insulation seam, 1 in. from penetrant insulation. |
| 10 | On steel plate insulation, 6 in. from penetrant insulation. |
| 11 | On steel plate insulation seam, 6 in. from penetrant insulation. |
| 12 | On top of penetrant. |

USNC142
ILL. 4

U.S. COAST GUARD
 UL Test No. 32 - D3/A60U
 86NK8673/USNC142
 6-24-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 65.4 | 65.7 | 65.3 | 66.5 |
| 4: 0 | 66.8 | 66.6 | 66.1 | 68.3 |
| 8: 0 | 67.5 | 67.2 | 67.3 | 75.5 |
| 12: 0 | 68.9 | 68.1 | 67.8 | 93.6 |
| 20: 0 | 75.9 | 71.7 | 69.0 | 111.7 |
| 24: 0 | 83.0 | 76.9 | 71.1 | 124.1 |
| 28: 0 | 111.4 | 88.4 | 74.8 | 139.7 |
| 32: 0 | 156.1 | 100.8 | 78.3 | 156.1 |
| 36: 0 | 198.8 | 112.6 | 81.6 | 170.3 |
| 40: 0 | 251.8 | 123.6 | 85.1 | 186.6 |
| 44: 0 | 302.4 | 131.2 | 88.8 | 202.5 |
| 48: 0 | 337.3 | 142.2 | 93.5 | 218.7 |
| 52: 0 | 365.3 | 153.1 | 98.5 | 235.7 |
| 56: 0 | 388.0 | 160.8 | 105.2 | 255.5 |
| 60: 0 | 404.2 | 169.2 | 112.3 | 266.1 |

FILE USNC142
 ILL. 5

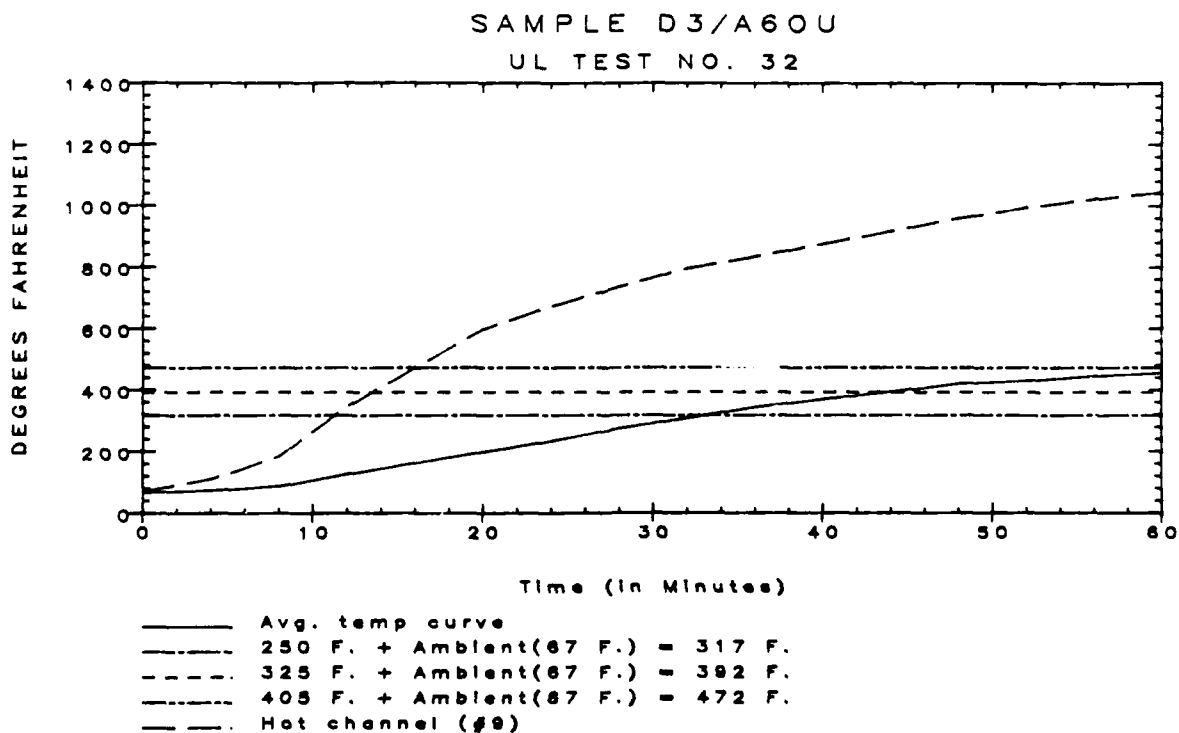
U.S. COAST GUARD
 UL Test No. 32 - D3/A60U
 86NK8673/USNC142
 6-24-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|--------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 65.5 | 68.1 | 72.1 | 68.3 |
| 4: 0 | 68.2 | 69.9 | 86.6 | 71.1 |
| 8: 0 | 70.4 | 73.1 | 120.8 | 73.9 |
| 12: 0 | 76.4 | 79.5 | 250.5 | 78.2 |
| 20: 0 | 94.2 | 101.7 | 572.9 | 108.3 |
| 24: 0 | 103.9 | 159.7 | 692.5 | 187.5 |
| 28: 0 | 112.9 | 280.0 | 778.1 | 299.2 |
| 32: 0 | 123.0 | 419.2 | 843.6 | 307.2 |
| 36: 0 | 132.1 | 501.2 | 888.5 | 452.8 |
| 40: 0 | 142.5 | 565.1 | 929.4 | 494.4 |
| 44: 0 | 152.9 | 609.3 | 968.4 | 524.2 |
| 48: 0 | 164.1 | 639.5 | 1091.5 | 546.3 |
| 52: 0 | 175.5 | 662.2 | 1028.0 | 566.1 |
| 56: 0 | 185.3 | 679.1 | 1049.7 | 581.7 |
| 60: 0 | 195.3 | 692.0 | 1069.4 | 593.7 |

FILE USNC142
 ILL. 5A

U.S. COAST GUARD
UL Test No. 32 - D3/A60U
86NK8673/USNC142
6-24-86

| | Temperature Degrees F | | | |
|------------|-----------------------|------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 70.5 | 66.1 | 69.7 | 64.9 |
| 4: 0 | 110.9 | 65.0 | 80.2 | 66.1 |
| 8: 0 | 183.9 | 63.8 | 124.6 | 67.9 |
| 12: 0 | 346.2 | 64.0 | 250.6 | 69.6 |
| 20: 0 | 598.5 | 69.2 | 428.3 | 82.4 |
| 24: 0 | 672.7 | 73.9 | 471.9 | 91.1 |
| 28: 0 | 735.7 | 79.4 | 502.6 | 97.9 |
| 32: 0 | 795.1 | 79.7 | 535.3 | 106.2 |
| 36: 0 | 835.0 | 80.0 | 560.2 | 113.1 |
| 40: 0 | 877.0 | 78.5 | 585.6 | 120.8 |
| 44: 0 | 917.2 | 89.8 | 611.5 | 127.5 |
| 48: 0 | 959.9 | 88.4 | 636.2 | 134.9 |
| 52: 0 | 994.7 | 90.6 | 655.6 | 142.1 |
| 56: 0 | 1022.4 | 92.8 | 670.8 | 148.1 |
| 60: 0 | 1045.6 | 86.6 | 685.1 | 154.4 |



T E S T R E C O R D D4/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D4/A60E and as shown in ILL. 6.

The fire and hose stream tests were conducted on June 12, 1986 and identified by UL as Test No. 14.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|--|
| 51 | No significant changes had occurred. |
| 52 | The bronze flange on the exposed side along with its insulation fell into the furnace chamber. |
| 60 | Test terminated. |

Temperature Of Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 7.

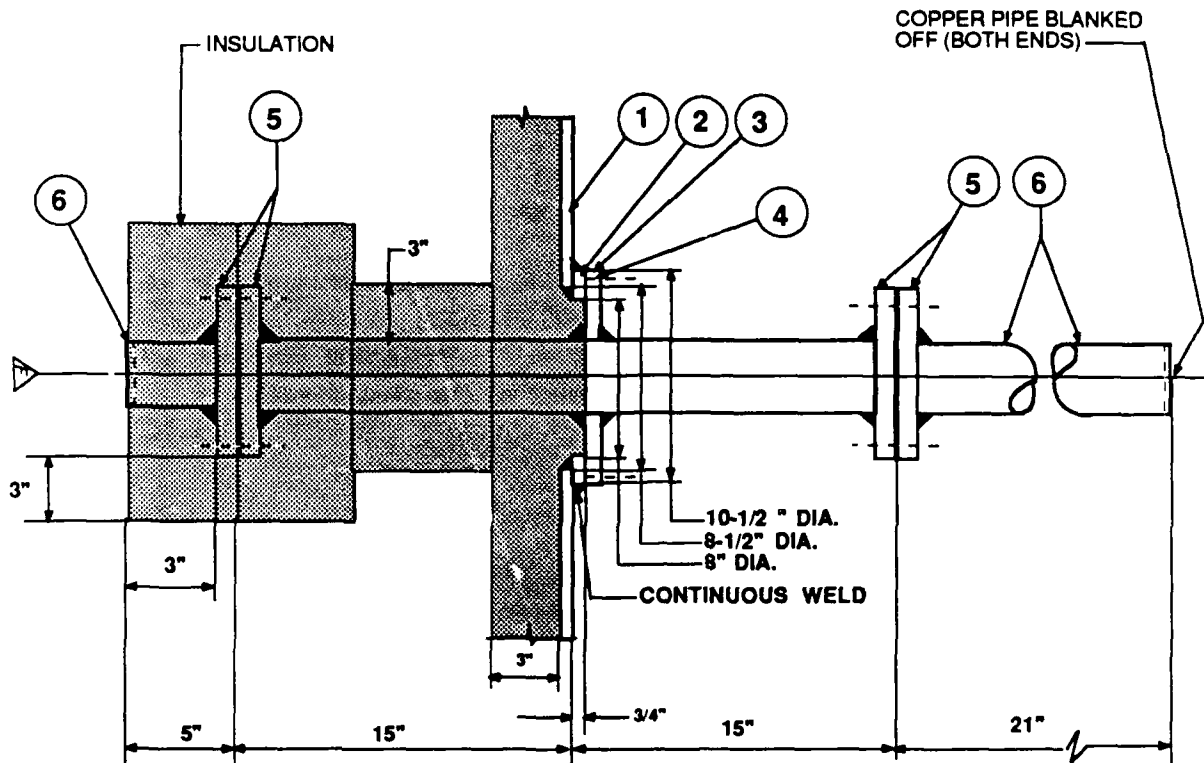
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 8 through 8B.

Hose Stream Test - No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D4/A60U
UL TEST NO. 14

- ① STEEL PLATE 36"x36"x3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② STEEL PAD 10-1/2" O.D. x 8" I.D. x 3/4" THICK.
ASTM A-53, GRADE A OR B.
- ③ BRONZE FLANGE, 10-1/2 O.D. x 5/8" THICK.
- ④ 5/8" DIA. STUDS, 4 REQUIRED.
- ⑤ 150 LBS BRONZE FLANGE
3" NOMINAL DIA. PIPE.
- ⑥ REGULAR COPPER PIPE,
3" NOMINAL DIA.



TEST SAMPLE NO. D-4A
COPPER PIPE WITH
COPPER SPIGOT

(R&DC GRAPHIC 3)

USNC 142
ILL. 6

SAMPLE D4/AGOE
TEST DATE JUNE 12, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 15 in. above steel plate. |
| 4 | On penetrant, 17 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | On 10-1/2 in. OD bronze flange, 3 in. from penetrant. |
| 7 | On 10-1/2 in. OD bronze flange, 3 in. from penetrant. |
| 8 | On steel plate over insulation, 5 in. from penetrant. |
| 9 | On steel plate over insulation seam, 5 in. from penetrant. |
| 10 | On steel plate over insulation, 12 in. from penetrant. |
| 11 | On steel plate over insulation seam, 12 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 7

U.S. COAST GUARD
UL Test No. 14 - D4/A60E
86NK8673/USNC142
6-12-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 73.7 | 73.5 | 72.2 | 72.1 |
| 4: 0 | 74.3 | 73.0 | 80.2 | 73.5 |
| 8: 0 | 75.5 | 74.9 | 72.6 | 72.6 |
| 12: 0 | 77.9 | 76.9 | 72.9 | 73.0 |
| 16: 0 | 81.9 | 79.0 | 73.4 | 73.4 |
| 20: 0 | 88.2 | 84.9 | 74.1 | 74.0 |
| 24: 0 | 97.1 | 92.8 | 75.2 | 76.3 |
| 28: 0 | 110.7 | 102.7 | 77.0 | 76.8 |
| 32: 0 | 127.6 | 116.8 | 80.7 | 79.2 |
| 36: 0 | 147.3 | 133.2 | 83.3 | 84.1 |
| 40: 0 | 168.5 | 150.8 | 88.8 | 86.0 |
| 44: 0 | 190.0 | 169.8 | 93.5 | 90.5 |
| 48: 0 | 212.4 | 188.0 | 98.3 | 95.6 |
| 52: 0 | 248.6 | 217.0 | 104.6 | 101.3 |
| 56: 0 | 294.7 | 255.2 | 112.7 | 108.2 |
| 60: 0 | 328.5 | 284.9 | 122.0 | 115.8 |

FILE USNC142
ILL. 8

U.S. COAST GUARD
 UL Test No. 14 - D4/A60E
 86NK8673/USNC142
 6-12-86

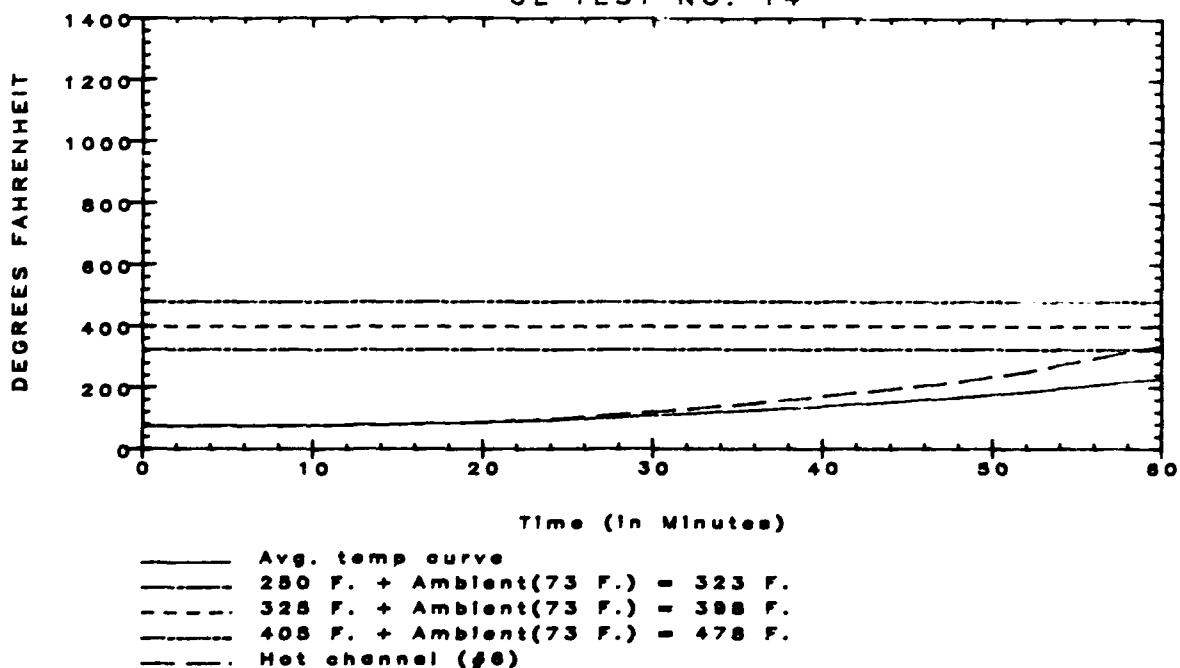
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NDS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 72.1 | 72.7 | 73.9 | 73.0 |
| 4: 0 | 73.5 | 73.0 | 74.4 | 74.5 |
| 8: 0 | 81.5 | 74.1 | 75.7 | 76.1 |
| 12: 0 | 73.1 | 76.5 | 78.4 | 79.1 |
| 16: 0 | 74.5 | 80.4 | 82.7 | 83.7 |
| 20: 0 | 75.1 | 86.8 | 88.0 | 92.2 |
| 24: 0 | 75.0 | 96.9 | 98.2 | 102.9 |
| 28: 0 | 76.2 | 111.3 | 111.4 | 118.2 |
| 32: 0 | 78.3 | 128.7 | 128.5 | 135.1 |
| 36: 0 | 80.4 | 149.3 | 147.9 | 152.4 |
| 40: 0 | 82.6 | 171.3 | 167.7 | 168.8 |
| 44: 0 | 85.7 | 193.9 | 188.5 | 189.8 |
| 48: 0 | 89.5 | 218.8 | 212.0 | 211.9 |
| 52: 0 | 93.8 | 251.6 | 241.9 | 235.0 |
| 56: 0 | 99.0 | 296.2 | 281.0 | 263.8 |
| 60: 0 | 104.4 | 337.0 | 326.5 | 295.6 |

FILE USNC142
 ILL. 8A

U.S. COAST GUARD
 UL Test No. 14 - D4/A60E
 86NK8673/USNC142
 6-12-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 74.1 | 75.2 | 74.3 | 73.1 |
| 4: 0 | 74.4 | 75.5 | 76.1 | 73.3 |
| 8: 0 | 78.5 | 78.4 | 78.0 | 73.5 |
| 12: 0 | 84.7 | 83.1 | 83.5 | 73.8 |
| 16: 0 | 92.3 | 90.7 | 88.9 | 74.1 |
| 20: 0 | 100.9 | 97.9 | 96.1 | 74.6 |
| 24: 0 | 110.7 | 112.3 | 107.5 | 75.2 |
| 28: 0 | 122.4 | 128.7 | 120.8 | 75.0 |
| 32: 0 | 135.3 | 146.0 | 134.6 | 77.2 |
| 36: 0 | 147.9 | 160.5 | 146.7 | 78.4 |
| 40: 0 | 160.9 | 175.2 | 158.0 | 80.2 |
| 44: 0 | 178.6 | 192.5 | 170.1 | 82.4 |
| 48: 0 | 202.4 | 209.3 | 182.5 | 85.2 |
| 52: 0 | 223.9 | 225.0 | 194.4 | 89.3 |
| 56: 0 | 248.7 | 238.6 | 209.9 | 94.1 |
| 60: 0 | 276.5 | 251.8 | 216.1 | 97.8 |

SAMPLE D4/A60E
 UL TEST NO. 14



T E S T R E C O R D D4/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D4/A60U and as shown in ILL. 9.

The fire and hose stream tests were conducted on July 18, 1986 and identified by UL as Test No. 37.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 15 | The bronze flange on the exposed side fell into the furnace chamber. |
| 20 | The steel plate along with the insulation was warping. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 10.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 11 through 11B. Due to a malfunction in the Data Logger System, the 0 min and the 4 min interval readings were not recorded.

HOSE STREAM TEST:

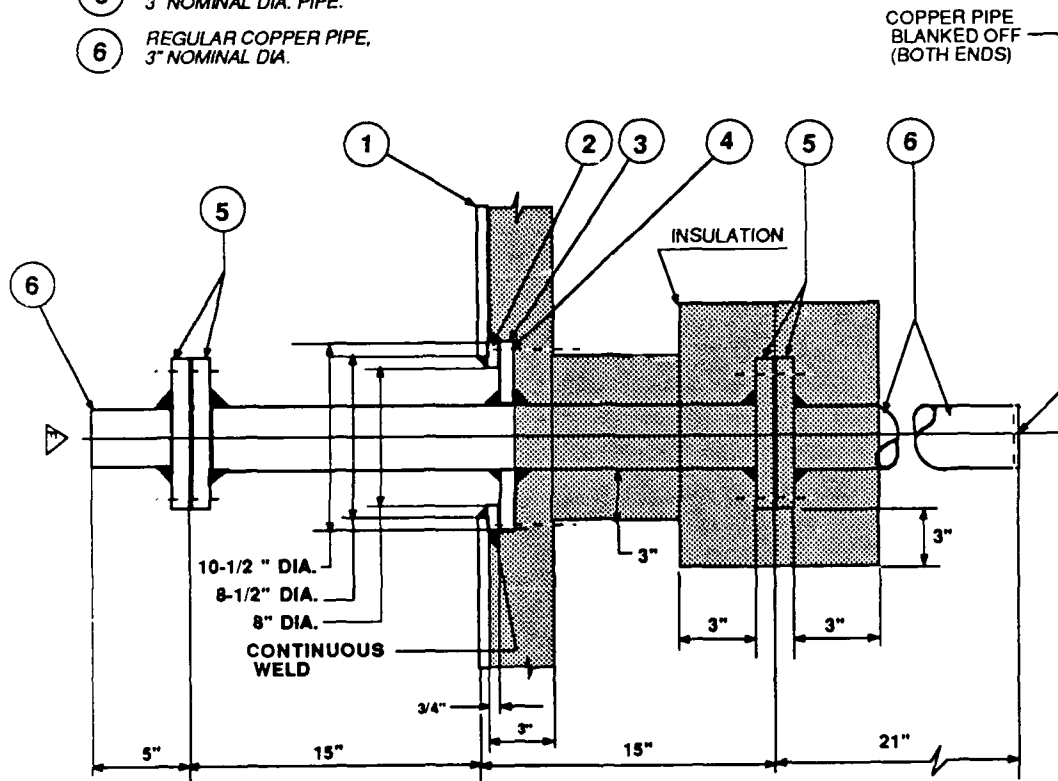
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D4/A60U
UL TEST NO. 37

- ① STEEL PLATE 36"x36"x3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② STEEL PAD 10-1/2" O.D. x 8" I.D. x 3/4" THICK.
ASTM A-53, GRADE A OR B.
- ③ BRONZE FLANGE, 10-1/2 O.D. x 5/8" THICK.
- ④ 5/8" DIA. STUDS, 4 REQUIRED.
- ⑤ 150 LBS BRONZE FLANGE
3" NOMINAL DIA. PIPE.
- ⑥ REGULAR COPPER PIPE,
3" NOMINAL DIA.



TEST SAMPLE NO. D-4A
COPPER PIPE WITH
COPPER SPIGOT
(R&DC GRAPHIC 2)

USNC 142
ILL. 9

SAMPLE D4/A60U
TEST DATE July 18, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 15 in. above steel plate. |
| 4 | On penetrant, 17 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | On steel plate insulation at interface of penetrant insulation. |
| 7 | On steel plate insulation seam at interface of penetrant insulation. |
| 8 | On steel plate insulation, 5 in. from penetrant. |
| 9 | On steel plate insulation seam, 5 in. from penetrant. |
| 10 | On steel plate insulation, 12 in. from penetrant. |
| 11 | On steel plate insulation seam, 12 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 10

U.S. COAST GUARD
 UL Test No. 37 - D4/A60U
 86MK8673/USNC142
 7-18-86

Temperature Degrees F

| CHAN(NOS.) | 1 | 2 | 3 | 4 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 8: 0 | 92.1 | 91.0 | 91.0 | 91.9 |
| 12: 0 | 93.6 | 92.9 | 93.3 | 92.7 |
| 16: 0 | 97.9 | 94.2 | 95.4 | 94.9 |
| 20: 0 | 109.6 | 97.8 | 99.9 | 96.6 |
| 24: 0 | 136.7 | 104.4 | 106.8 | 100.0 |
| 28: 0 | 199.3 | 115.8 | 117.0 | 104.5 |
| 32: 0 | 307.1 | 136.1 | 131.3 | 111.6 |
| 36: 0 | 407.1 | 169.4 | 146.6 | 119.2 |
| 40: 0 | 481.4 | 198.6 | 160.4 | 126.1 |
| 44: 0 | 549.5 | 236.1 | 175.3 | 133.7 |
| 48: 0 | 606.7 | 273.3 | 188.9 | 139.7 |
| 52: 0 | 650.1 | 310.7 | 206.0 | 147.5 |
| 56: 0 | 678.5 | 343.7 | 225.0 | 156.4 |
| 60: 0 | 694.0 | 367.8 | 240.6 | 162.9 |

FILE USNC142
 ILL. 11

U.S. COAST GUARD
 UL Test No. 37 - D4/A60U
 86NK8673/USNC142
 7-18-86

| Temperature Degrees F | | | | |
|-----------------------|-------|--------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 8: 0 | 95.7 | 103.1 | 94.3 | 93.4 |
| 12: 0 | 102.7 | 121.7 | 99.3 | 97.0 |
| 16: 0 | 110.1 | 171.1 | 118.6 | 105.1 |
| 20: 0 | 122.2 | 277.7 | 166.9 | 129.2 |
| 24: 0 | 136.1 | 457.4 | 267.3 | 197.7 |
| 28: 0 | 153.7 | 662.7 | 457.9 | 327.1 |
| 32: 0 | 174.0 | 819.5 | 630.8 | 453.8 |
| 36: 0 | 196.2 | 891.3 | 740.6 | 517.0 |
| 40: 0 | 218.0 | 949.2 | 804.6 | 557.8 |
| 44: 0 | 239.6 | 1014.1 | 858.1 | 598.6 |
| 48: 0 | 259.9 | 1077.0 | 904.2 | 643.4 |
| 52: 0 | 281.1 | 1125.9 | 941.5 | 688.4 |
| 56: 0 | 300.8 | 1163.2 | 969.0 | 721.6 |
| 60: 0 | 318.4 | 1189.5 | 988.1 | 743.3 |

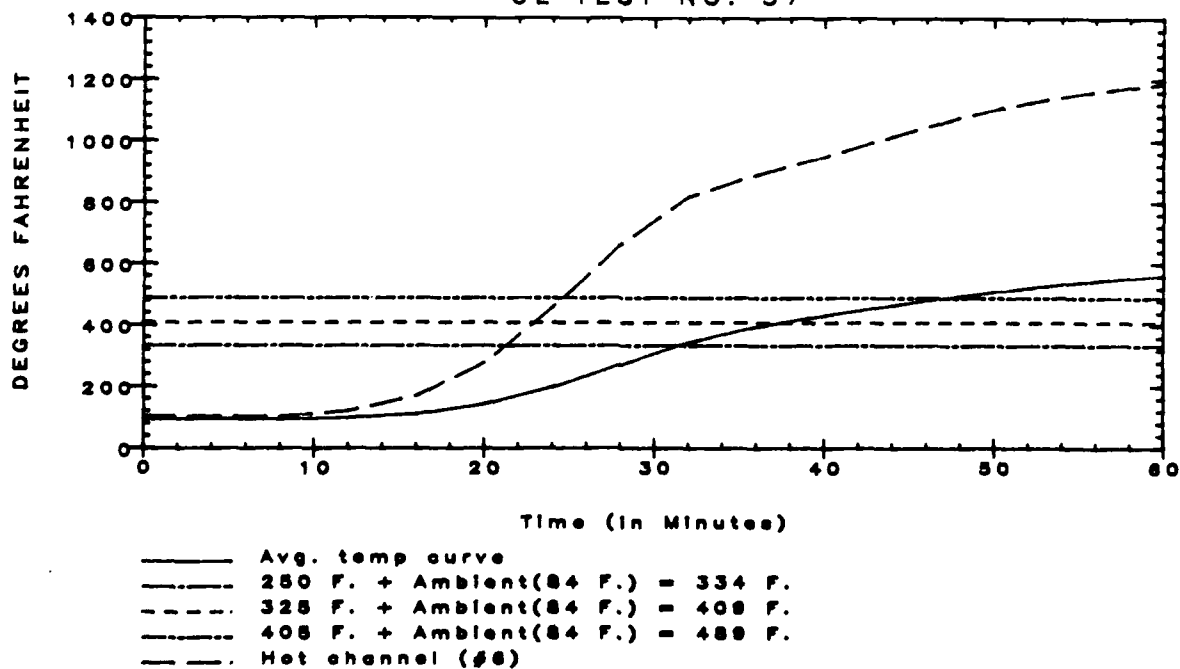
FILE USNC142
 ILL. 11A

U.S. COAST GUARD
 UL Test No. 37 - D4/A60U
 86NK8673/USNC142
 7-18-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 8: 0 | 94.1 | 93.1 | 95.6 | 91.9 |
| 12: 0 | 95.5 | 94.9 | 105.0 | 95.2 |
| 16: 0 | 105.0 | 95.7 | 155.1 | 100.2 |
| 20: 0 | 131.3 | 101.2 | 286.2 | 108.5 |
| 24: 0 | 188.6 | 121.4 | 442.5 | 117.7 |
| 28: 0 | 283.7 | 173.1 | 538.6 | 127.3 |
| 32: 0 | 370.2 | 269.3 | 595.0 | 138.1 |
| 36: 0 | 419.7 | 354.7 | 633.3 | 150.0 |
| 40: 0 | 458.7 | 397.8 | 667.9 | 161.9 |
| 44: 0 | 495.2 | 418.7 | 694.6 | 173.3 |
| 48: 0 | 529.2 | 431.8 | 713.8 | 183.1 |
| 52: 0 | 559.7 | 443.1 | 729.1 | 194.2 |
| 56: 0 | 585.2 | 455.4 | 743.4 | 209.0 |
| 60: 0 | 600.1 | 472.2 | 753.6 | 221.4 |

SAMPLE D4/A60U
 UL TEST NO. 37



T E S T R E C O R D D5/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D5/A60U and as shown in ILL. 12.

The fire and hose stream tests were conducted on June 11, 1986 and identified by UL as Test No. 12.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 20 | The bronze flange on the exposed side had fallen off the assembly and dropped inside the furnace chamber. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 13.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 14 through 14B. Thermocouple No. 8 was inoperable after the 20 min interval reading.

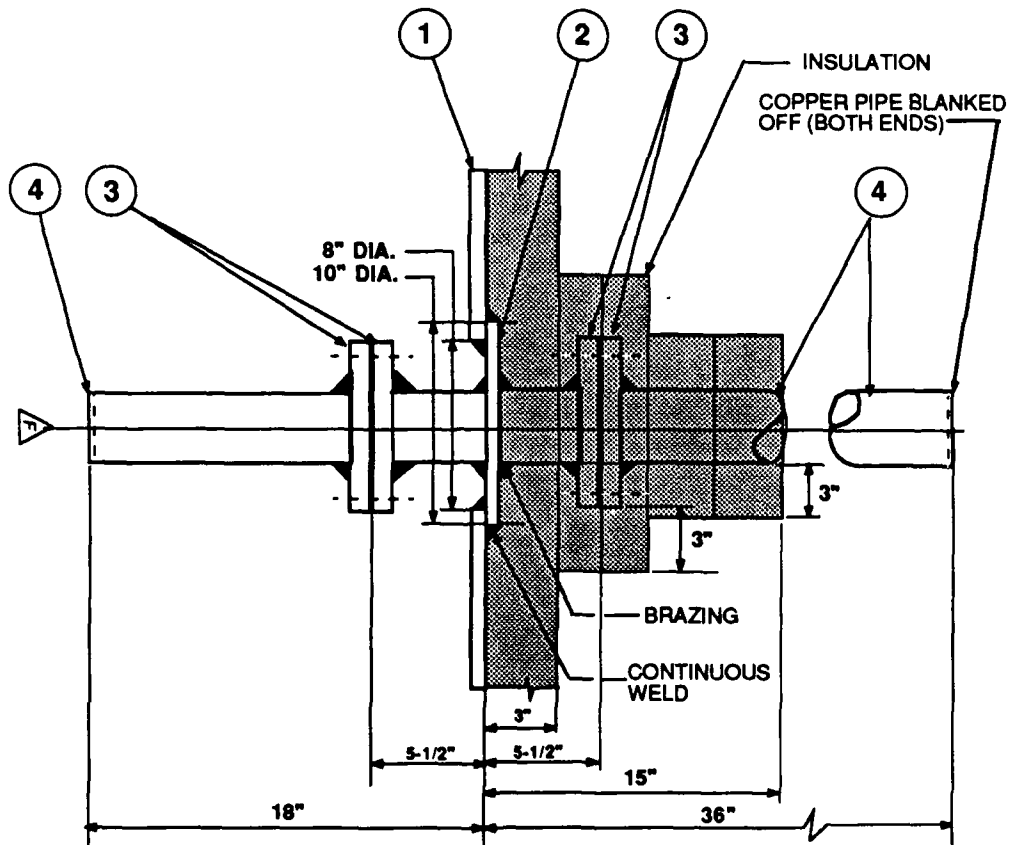
Pressure Record - The pressure within the small-scale test furnace ranged from +0.005 in./H₂O (+1.24 Pa) to +0.01 in./H₂O (+2.5 Pa) throughout the duration of the fire endurance test.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE, 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② STEEL PLATE COLLAR 10" DIA. X 3/16" THICK.
ASTM A-53, GRADE A OR B.
- ③ 150 LBS BRONZE FLANGE
3" NOMINAL DIA. PIPE SIZE.
- ④ REGULAR COPPER PIPE
3" NOMINAL DIA.



**TEST SAMPLE NO. D-5A
COPPER PIPE WITH
COPPER SPIGOT**

(R&DC GRAPHIC 4)

USNC 142
ILL.12

SAMPLE D5/A60U
TEST DATE JUNE 11, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On pcnetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, 18 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | On steel plate insulation, at interface of penetrant insulation. |
| 7 | On steel plate insulation seam, at interface of penetrant insulation. |
| 8 | On top of penetrant. |
| 9 | On steel plate insulation, 3 in. from penetrant insulation. |
| 10 | On steel plate insulation seam, 3 in. from penetrant insulation. |
| 11 | On steel plate insulation, 9 in. from penetrant insulation. |
| 12 | On steel plate insulation seam, 9 in. from penetrant insulation. |

USNC142
ILL. 13

U.S. COAST GUARD
 UL Test No. 12 - D5/A60U
 86NK8673/USNC142
 6-11-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 86.8 | 86.0 | 86.8 | 86.7 |
| 4: 0 | 86.8 | 86.8 | 86.8 | 86.8 |
| 8: 0 | 87.3 | 87.2 | 87.4 | 92.2 |
| 12: 0 | 88.3 | 87.5 | 87.9 | 101.8 |
| 16: 0 | 90.1 | 88.1 | 88.5 | 113.0 |
| 20: 0 | 92.2 | 89.6 | 89.9 | 129.3 |
| 24: 0 | 94.7 | 93.1 | 90.8 | 149.9 |
| 28: 0 | 105.9 | 98.8 | 93.4 | 172.8 |
| 32: 0 | 130.4 | 109.7 | 96.4 | 197.7 |
| 36: 0 | 170.0 | 120.2 | 100.7 | 222.2 |
| 40: 0 | 216.8 | 130.4 | 103.8 | 246.0 |
| 44: 0 | 263.6 | 139.8 | 107.8 | 271.5 |
| 48: 0 | 304.5 | 150.4 | 111.8 | 295.3 |
| 52: 0 | 340.0 | 163.3 | 115.8 | 318.8 |
| 56: 0 | 370.4 | 180.2 | 120.8 | 340.6 |
| 60: 0 | 399.1 | 197.5 | 126.2 | 360.6 |

FILE USNC142
 ILL. 14

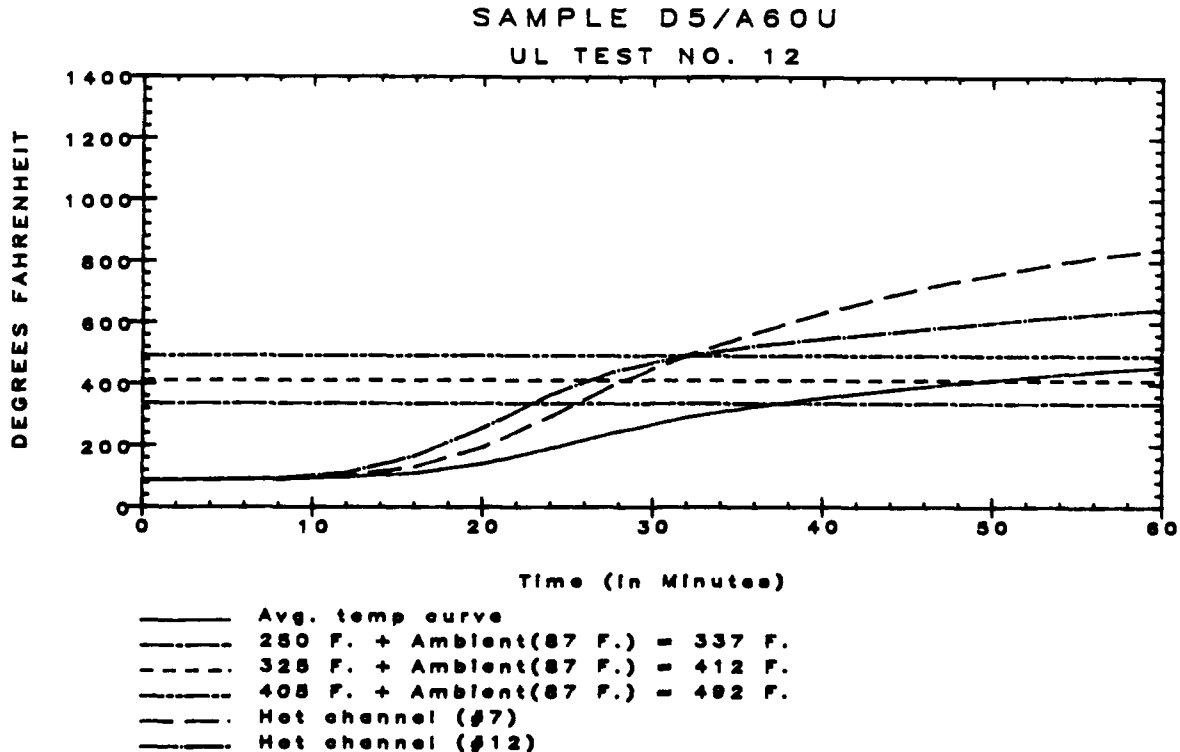
U.S. COAST GUARD
 UL Test No. 12 - D5/A60U
 86NK8673/USNC142
 6-11-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 86.7 | 86.6 | 87.9 | 87.1 |
| 4: 0 | 86.3 | 87.9 | 88.0 | 87.5 |
| 8: 0 | 90.5 | 90.7 | 92.8 | 88.7 |
| 12: 0 | 96.0 | 109.6 | 102.2 | 91.4 |
| 16: 0 | 103.9 | 106.6 | 131.4 | 94.9 |
| 20: 0 | 114.5 | 141.2 | 195.1 | 101.1 |
| 24: 0 | 128.7 | 222.7 | 295.9 | ----- |
| 28: 0 | 145.1 | 342.5 | 405.2 | ----- |
| 32: 0 | 163.7 | 466.0 | 493.1 | ----- |
| 36: 0 | 182.1 | 560.3 | 567.6 | ----- |
| 40: 0 | 200.2 | 629.6 | 631.9 | ----- |
| 44: 0 | 220.0 | 679.7 | 689.8 | ----- |
| 48: 0 | 238.4 | 712.2 | 738.3 | ----- |
| 52: 0 | 256.7 | 739.7 | 777.7 | ----- |
| 56: 0 | 274.9 | 765.3 | 815.6 | ----- |
| 60: 0 | 290.9 | 782.3 | 841.2 | ----- |

FILE USNC142
 ILL. 14A

U.S. COAST GUARD
UL Test No. 12 - D5/A60U
86NK8673/USNC142
6-11-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|------|-------|
| CHAN(NDS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 88.2 | 88.4 | 86.5 | 87.9 |
| 4: 0 | 89.2 | 89.9 | 86.4 | 90.2 |
| 8: 0 | 90.7 | 93.6 | 86.5 | 94.7 |
| 12: 0 | 95.1 | 101.8 | 86.7 | 111.8 |
| 16: 0 | 98.9 | 129.5 | 86.9 | 167.5 |
| 20: 0 | 128.0 | 196.4 | 87.1 | 257.7 |
| 24: 0 | 204.8 | 306.3 | 95.2 | 366.6 |
| 28: 0 | 325.2 | 402.7 | 87.8 | 446.7 |
| 32: 0 | 429.9 | 451.0 | 88.3 | 491.4 |
| 36: 0 | 488.3 | 478.9 | 88.6 | 525.9 |
| 40: 0 | 518.8 | 502.3 | 88.9 | 548.1 |
| 44: 0 | 540.2 | 524.9 | 88.1 | 570.3 |
| 48: 0 | 559.4 | 547.4 | 89.6 | 591.4 |
| 52: 0 | 576.7 | 568.7 | 90.1 | 612.0 |
| 56: 0 | 592.6 | 588.1 | 90.2 | 629.5 |
| 60: 0 | 604.7 | 603.6 | 90.8 | 645.7 |



T E S T R E C O R D D6/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D6/A60U and as shown in ILL. 15.

The fire and hose stream tests were conducted on July 18, 1986 and identified by UL as Test No. 38.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 15 | The bronze flange on the exposed side fell into the furnace chamber. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 16.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 17 through 17B.

HOSE STREAM TEST:

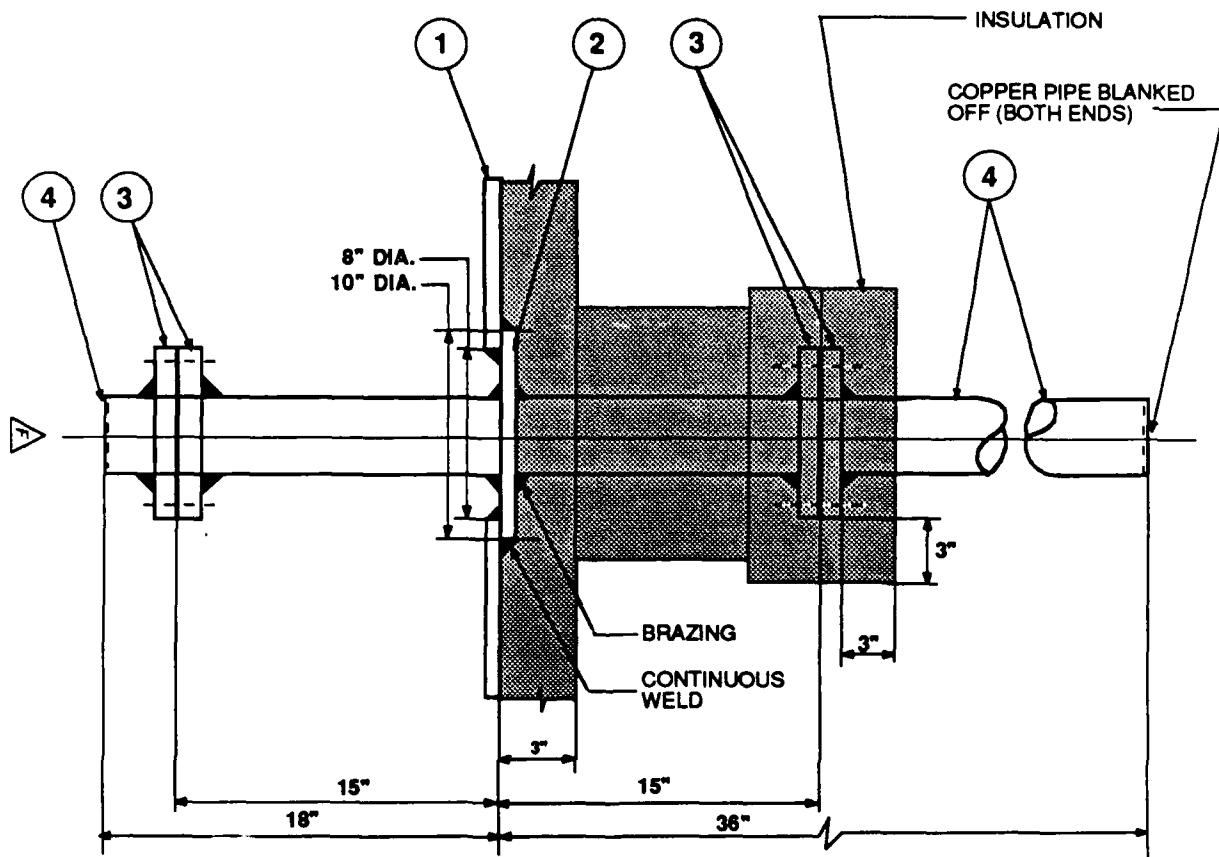
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D6/A60U
UL TEST NO. 38

- ① STEEL PLATE, 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② STEEL PLATE COLLAR 10" DIA. X 3/16" THICK.
ASTM A-53, GRADE A OR B.
- ③ 150 LBS BRONZE FLANGE
3" NOMINAL DIA. PIPE SIZE.
- ④ REGULAR COPPER PIPE
3" NOMINAL DIA.



TEST SAMPLE NO. D-6A
COPPER PIPE WITH
COPPER SPIGOT

(R&DC GRAPHIC 5)

USNC 142
ILL. 15

SAMPLE D6/A60U
TEST DATE July 18, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, 18 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | On steel plate insulation at interface of penetrant insulation. |
| 7 | On steel plate insulation seam at interface of penetrant insulation. |
| 8 | On steel plate insulation, 8-1/2 in. from penetrant. |
| 9 | On steel plate insulation seam, 8-1/2 in. from penetrant. |
| 10 | On steel plate insulation, 14-1/2 in. from penetrant. |
| 11 | On steel plate insulation seam, 14-1/2 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 16

U. S. COAST GUARD
 UL Test No. 38 - D6/A60U
 86NK8673/USNC142
 7-18-86

Temperature Degrees F

| CHAN(NOS.) | 1 | 2 | 3 | 4 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 97.2 | 97.1 | 97.1 | 96.7 |
| 4: 0 | 98.0 | 97.6 | 97.5 | 97.2 |
| 8: 0 | 98.9 | 98.5 | 98.6 | 98.2 |
| 12: 0 | 100.3 | 99.9 | 99.9 | 99.7 |
| 16: 0 | 102.4 | 102.3 | 102.1 | 102.2 |
| 20: 0 | 108.3 | 106.8 | 105.7 | 107.0 |
| 24: 0 | 123.3 | 115.8 | 118.1 | 114.2 |
| 28: 0 | 155.3 | 131.3 | 122.6 | 126.0 |
| 32: 0 | 214.7 | 151.1 | 134.4 | 136.7 |
| 36: 0 | 304.0 | 175.4 | 148.9 | 150.0 |
| 40: 0 | 369.4 | 203.7 | 166.3 | 165.7 |
| 44: 0 | 407.3 | 233.2 | 184.2 | 181.4 |
| 48: 0 | 429.5 | 260.8 | 201.8 | 196.2 |
| 52: 0 | 446.9 | 287.4 | 221.2 | 211.2 |
| 56: 0 | 456.5 | 303.7 | 235.8 | 222.9 |
| 60: 0 | 465.5 | 317.7 | 250.5 | 237.3 |

FILE USNC142
 ILL. 17

U. S. COAST GUARD
 UL Test No. 38 - D6/A60U
 86NK8673/USNC142
 7-18-86

Temperature Degrees F

| CHAN(NOS.) | 5 | 6 | 7 | 8 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 96.3 | 101.6 | 97.3 | 97.7 |
| 4: 0 | 98.8 | 102.9 | 99.4 | 98.6 |
| 8: 0 | 104.3 | 104.1 | 102.0 | 99.8 |
| 12: 0 | 113.3 | 105.8 | 107.9 | 102.7 |
| 16: 0 | 125.4 | 106.9 | 129.3 | 115.7 |
| 20: 0 | 140.2 | 116.7 | 199.9 | 160.2 |
| 24: 0 | 158.1 | 150.5 | 350.6 | 262.5 |
| 28: 0 | 174.8 | 232.5 | 563.7 | 401.2 |
| 32: 0 | 192.1 | 398.5 | 669.1 | 468.2 |
| 36: 0 | 210.1 | 561.3 | 710.2 | 491.6 |
| 40: 0 | 229.7 | 624.0 | 736.3 | 507.8 |
| 44: 0 | 247.7 | 654.7 | 759.3 | 520.2 |
| 48: 0 | 265.5 | 676.1 | 781.2 | 532.5 |
| 52: 0 | 282.9 | 695.1 | 800.6 | 544.7 |
| 56: 0 | 296.4 | 711.3 | 816.5 | 554.0 |
| 60: 0 | 312.0 | 726.7 | 831.6 | 565.2 |

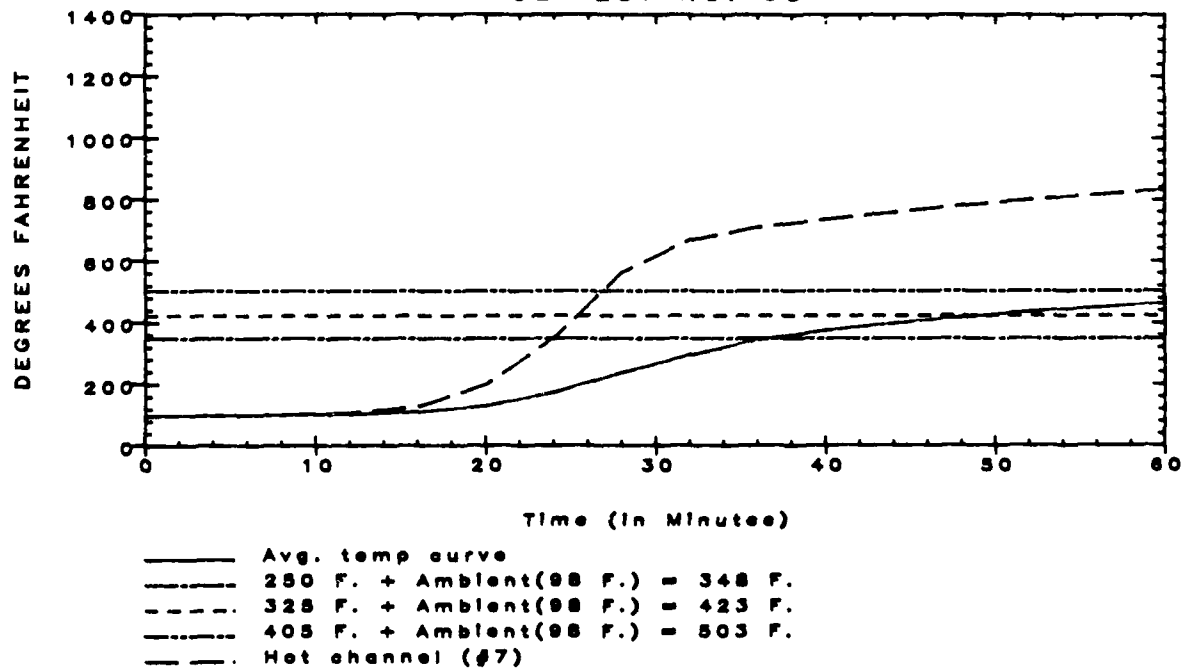
FILE USNC142
 ILL. 17A

U. S. COAST GUARD
 UL Test No. 38 - D6/A60U
 86NK8673/USNC142
 7-18-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 98.6 | 101.9 | 98.0 | 97.5 |
| 4: 0 | 100.7 | 102.6 | 100.4 | 98.1 |
| 8: 0 | 105.9 | 102.1 | 108.3 | 101.0 |
| 12: 0 | 115.8 | 103.9 | 121.4 | 106.3 |
| 16: 0 | 147.0 | 105.3 | 147.2 | 114.6 |
| 20: 0 | 214.2 | 109.5 | 201.5 | 124.9 |
| 24: 0 | 306.5 | 124.0 | 297.2 | 135.8 |
| 28: 0 | 384.3 | 155.7 | 390.6 | 146.5 |
| 32: 0 | 428.0 | 208.5 | 447.6 | 156.0 |
| 36: 0 | 453.3 | 269.7 | 481.2 | 165.4 |
| 40: 0 | 468.8 | 320.6 | 502.4 | 177.4 |
| 44: 0 | 483.1 | 356.4 | 517.8 | 189.7 |
| 52: 0 | 506.8 | 398.2 | 540.6 | 213.2 |
| 56: 0 | 515.8 | 410.1 | 549.0 | 223.0 |
| 60: 0 | 524.1 | 421.6 | 557.6 | 233.1 |

SAMPLE D6/A60U
 UL TEST NO. 38



T E S T R E C O R D D9/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D9/A60U and as shown on ILL. 18.

The fire and hose stream tests were conducted on June 16, 1986 and identified by UL as Test No. 20.

RESULTS

Observations During Fire Test - All observations referenced to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 25 | No significant changes had occurred. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 19.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 20 through 20B.

HOSE STREAM TEST:

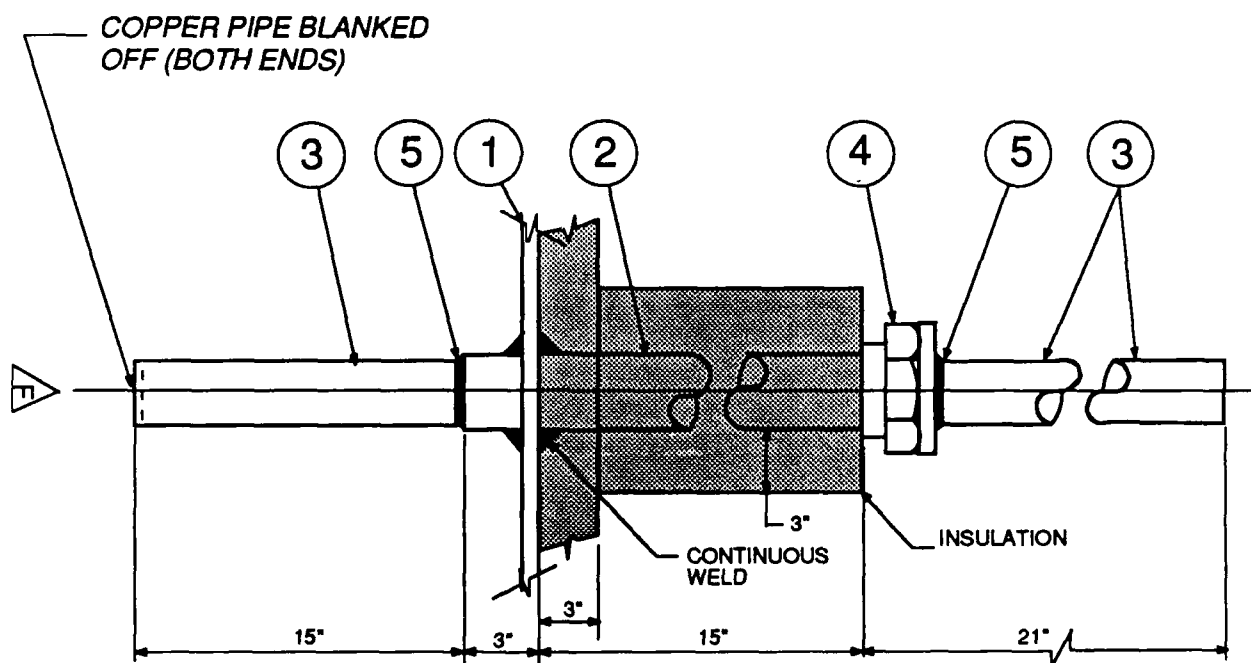
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D9/A60U
UL TEST NO. 20

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3-1/2" NOMINAL
DIA. SCHEDULE 40.
- ③ REGULAR COPPER PIPE, 3" NOMINAL DIA.
- ④ BRASS TERMINAL TUBE "KONDU" TYPE V-312 FP,
WITH PILOT HOLE, DRILLED TO SUIT COPPER PIPE.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-9A
COPPER PIPE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE

(R&DC GRAPHIC 6)

USNC 142
ILL. 18

SAMPLE D9/A60U
TEST DATE JUNE 16, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On brass terminal tube. |
| 5 | On penetrant, at interface of steel pipe and copper pipe. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate insulation, at interface of penetrant insulation. |
| 8 | On top of penetrant. |
| 9 | On steel plate insulation, 6 in. from penetrant. |
| 10 | On steel plate insulation seam, 6 in. from penetrant. |
| 11 | On steel plate insulation, 12 in. from penetrant. |
| 12 | On steel plate insulation seam, 12 in. from penetrant. |

USNC142
ILL. 19

U.S. COAST GUARD
UL Test No. 20 - D9/A60U
86NK8673/USNC142
6-16-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 86.1 | 86.4 | 85.0 | 84.2 |
| 4: 0 | 86.8 | 87.4 | 86.1 | 86.5 |
| 8: 0 | 88.2 | 89.4 | 86.7 | 111.3 |
| 12: 0 | 90.3 | 92.6 | 87.8 | 154.3 |
| 16: 0 | 91.4 | 94.7 | 88.7 | 178.5 |
| 20: 0 | 94.1 | 98.0 | 89.4 | 196.2 |
| 24: 0 | 102.2 | 103.2 | 92.9 | 212.3 |
| 28: 0 | 124.3 | 112.9 | 97.3 | 231.1 |
| 32: 0 | 163.4 | 128.7 | 105.5 | 254.4 |
| 36: 0 | 210.7 | 143.2 | 113.4 | 280.7 |
| 40: 0 | 252.8 | 157.1 | 120.7 | 307.2 |
| 44: 0 | 287.3 | 170.6 | 128.9 | 331.9 |
| 48: 0 | 313.3 | 184.0 | 136.9 | 356.9 |
| 52: 0 | 334.8 | 198.3 | 145.3 | 380.6 |
| 56: 0 | 353.1 | 214.0 | 154.6 | 402.9 |
| 60: 0 | 369.9 | 228.7 | 164.5 | 423.8 |

FILE USNC142
ILL. 20

U.S. COAST GUARD
 UL Test No. 20 - D9/A60U
 86NK8673/USNC142
 6-16-86

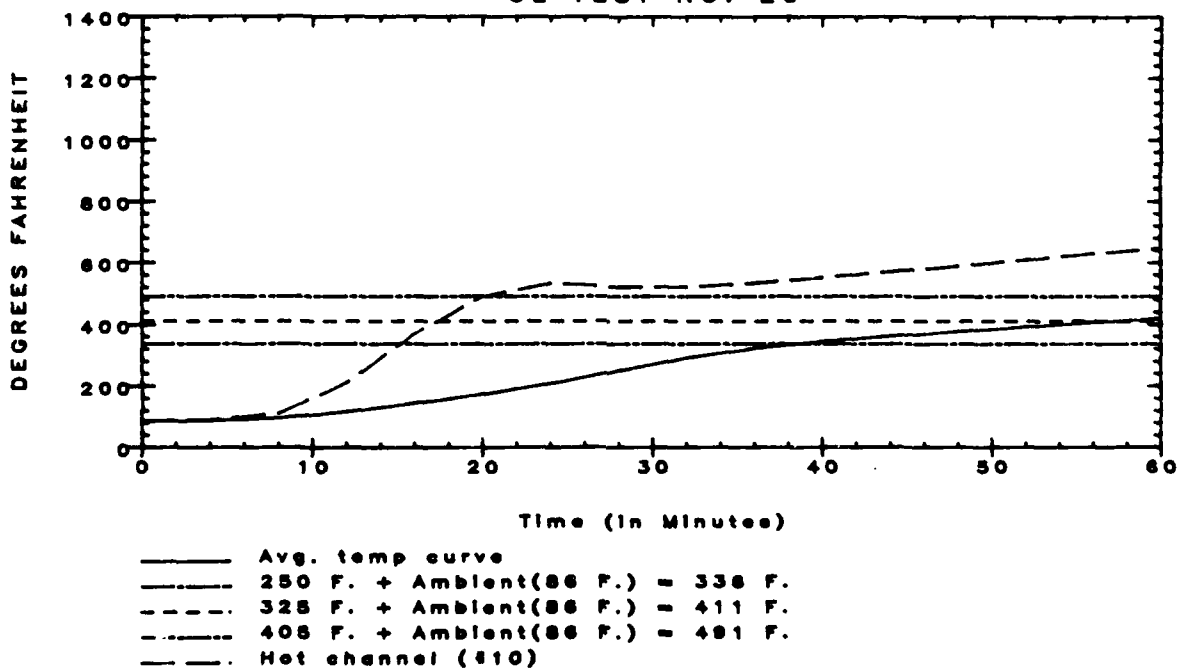
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 84.0 | 84.5 | 86.1 | 85.0 |
| 4: 0 | 85.2 | 87.6 | 85.8 | 87.6 |
| 8: 0 | 86.5 | 103.5 | 88.3 | 93.5 |
| 12: 0 | 92.5 | 133.6 | 91.9 | 106.0 |
| 16: 0 | 93.6 | 161.9 | 93.8 | 124.5 |
| 20: 0 | 95.6 | 188.2 | 109.1 | 142.7 |
| 24: 0 | 97.2 | 213.0 | 161.8 | 161.1 |
| 28: 0 | 99.7 | 234.9 | 273.4 | 179.3 |
| 32: 0 | 104.0 | 255.0 | 435.2 | 195.4 |
| 36: 0 | 106.6 | 274.9 | 557.5 | 210.8 |
| 40: 0 | 114.0 | 294.8 | 610.7 | 225.4 |
| 44: 0 | 115.0 | 310.3 | 640.3 | 237.7 |
| 48: 0 | 116.4 | 326.8 | 662.4 | 250.2 |
| 52: 0 | 122.2 | 342.7 | 680.5 | 262.0 |
| 56: 0 | 126.9 | 357.6 | 696.9 | 273.6 |
| 60: 0 | 132.6 | 371.0 | 710.2 | 283.7 |

FILE USNC142
 ILL. 20A

U.S. COAST GUARD
 UL Test No. 20 - D9/A60U
 86NK8673/USNC142
 6-16-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 86.5 | 86.6 | 86.0 | 87.5 |
| 4: 0 | 87.6 | 89.1 | 87.8 | 91.8 |
| 8: 0 | 89.5 | 111.5 | 91.8 | 112.9 |
| 12: 0 | 93.3 | 211.2 | 96.9 | 166.8 |
| 16: 0 | 96.4 | 370.3 | 109.5 | 245.0 |
| 20: 0 | 119.7 | 491.1 | 153.7 | 316.4 |
| 24: 0 | 186.0 | 533.8 | 266.6 | 372.3 |
| 28: 0 | 304.0 | 520.5 | 414.8 | 403.9 |
| 32: 0 | 407.1 | 521.4 | 509.0 | 422.4 |
| 36: 0 | 464.1 | 534.8 | 543.0 | 438.2 |
| 40: 0 | 497.3 | 552.5 | 561.7 | 448.3 |
| 44: 0 | 520.7 | 571.4 | 578.2 | 460.4 |
| 48: 0 | 540.1 | 590.4 | 592.1 | 470.7 |
| 52: 0 | 557.6 | 610.9 | 605.4 | 481.1 |
| 56: 0 | 574.2 | 630.4 | 617.2 | 495.1 |
| 60: 0 | 586.3 | 648.2 | 626.7 | 506.3 |

SAMPLE D9/A60U
 UL TEST NO. 20



T E S T R E C O R D D10/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D10/A60E and as shown in ILL. 21.

The fire and hose stream tests were conducted on June 13, 1986 and identified by UL as Test No. 15.

RESULTS

Observations During Fire Test - All observations referenced to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|--|
| 60 | No significant changes occurred during the duration of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 22.

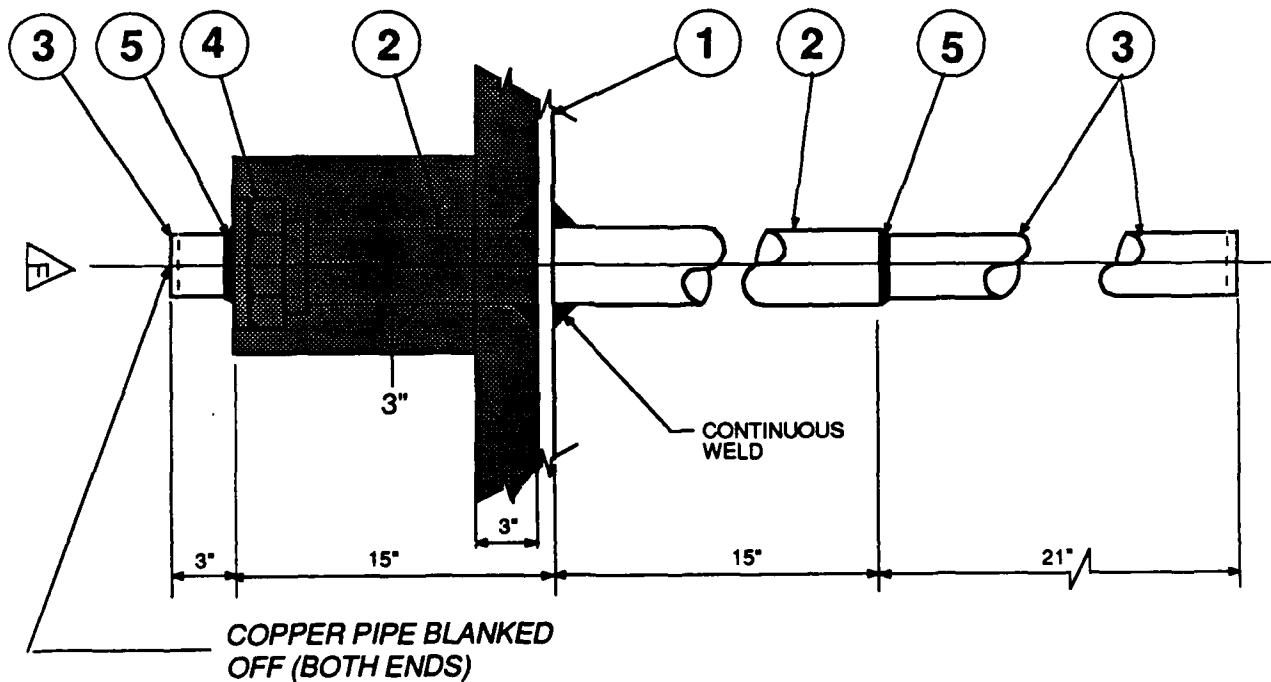
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 23 through 23B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3-1/2" NOMINAL
DIA. SCHEDULE 40.
- ③ REGULAR COPPER PIPE, 3" NOMINAL DIA.
- ④ BRASS TERMINAL TUBE "KONDU" TYPE V-312 FP,
WITH PILOT HOLE, DRILLED TO SUIT COPPER PIPE.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-10A
COPPER PIPE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE

(R&DC GRAPHIC 9)

USNC 142
ILL. 21

SAMPLE D10/A60E
TEST DATE JUNE 13, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 1 in. above interface of steel pipe and copper pipe. |
| 3 | On penetrant, 6 in. above steel plate. |
| 4 | On penetrant, 12 in. above steel plate. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate, at interface of penetrant. |
| 8 | On steel plate over insulation, 1 in. from penetrant. |
| 9 | On steel plate over insulation seam, 1 in. from penetrant. |
| 10 | On steel plate over insulation, 6 in. from penetrant. |
| 11 | On steel plate over insulation seam, 6 in. from penetrant. |
| 12 | On steel plate over insulation, 12 in. from penetrant. |
| 13 | On steel plate over insulation seam, 12 in. from penetrant. |

USNC142
ILL. 22

U.S. COAST GUARD
 UL Test No. 15 - D10/A60E
 86NK8673/USNC142
 6-13-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 73.0 | 73.7 | 72.9 | 72.8 |
| 4: 0 | 74.2 | 74.1 | 74.4 | 73.0 |
| 8: 0 | 74.8 | 75.7 | 74.7 | 73.5 |
| 12: 0 | 76.6 | 80.9 | 75.0 | 74.6 |
| 16: 0 | 80.3 | 91.1 | 78.0 | 77.5 |
| 20: 0 | 86.6 | 104.7 | 84.2 | 81.6 |
| 24: 0 | 95.0 | 122.2 | 90.9 | 88.3 |
| 28: 0 | 107.9 | 140.1 | 101.4 | 97.2 |
| 32: 0 | 123.8 | 156.8 | 114.6 | 107.5 |
| 36: 0 | 142.6 | 174.3 | 130.2 | 119.3 |
| 40: 0 | 162.1 | 189.3 | 147.1 | 131.6 |
| 44: 0 | 181.4 | 204.0 | 164.8 | 145.1 |
| 48: 0 | 201.3 | 218.4 | 181.0 | 157.8 |
| 52: 0 | 220.4 | 233.4 | 197.1 | 170.6 |
| 56: 0 | 238.1 | 246.8 | 212.7 | 182.2 |
| 60: 0 | 252.5 | 259.6 | 225.7 | 191.9 |

FILE USNC142
 ILL. 23

U.S. COAST GUARD
 UL Test No. 15 - D10/A60E
 86NK8673/USNC142
 6-13-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 72.6 | 72.4 | 73.1 | 72.7 |
| 4: 0 | 73.9 | 72.6 | 73.3 | 72.8 |
| 8: 0 | 75.1 | 73.3 | 74.8 | 72.8 |
| 12: 0 | 78.6 | 75.1 | 77.7 | 72.8 |
| 16: 0 | 84.9 | 78.9 | 84.4 | 73.6 |
| 20: 0 | 95.9 | 85.0 | 95.2 | 74.3 |
| 24: 0 | 109.5 | 93.4 | 112.2 | 73.0 |
| 28: 0 | 124.5 | 103.0 | 133.6 | 75.5 |
| 32: 0 | 138.6 | 112.9 | 158.2 | 74.1 |
| 36: 0 | 154.0 | 124.5 | 185.0 | 74.3 |
| 40: 0 | 166.8 | 133.0 | 213.5 | 74.2 |
| 44: 0 | 179.6 | 142.8 | 243.3 | 224.2 |
| 48: 0 | 192.3 | 152.2 | 271.5 | 248.6 |
| 52: 0 | 205.8 | 162.6 | 298.0 | 271.2 |
| 56: 0 | 217.3 | 171.9 | 321.5 | 292.3 |
| 60: 0 | 228.3 | 179.5 | 342.0 | 309.8 |

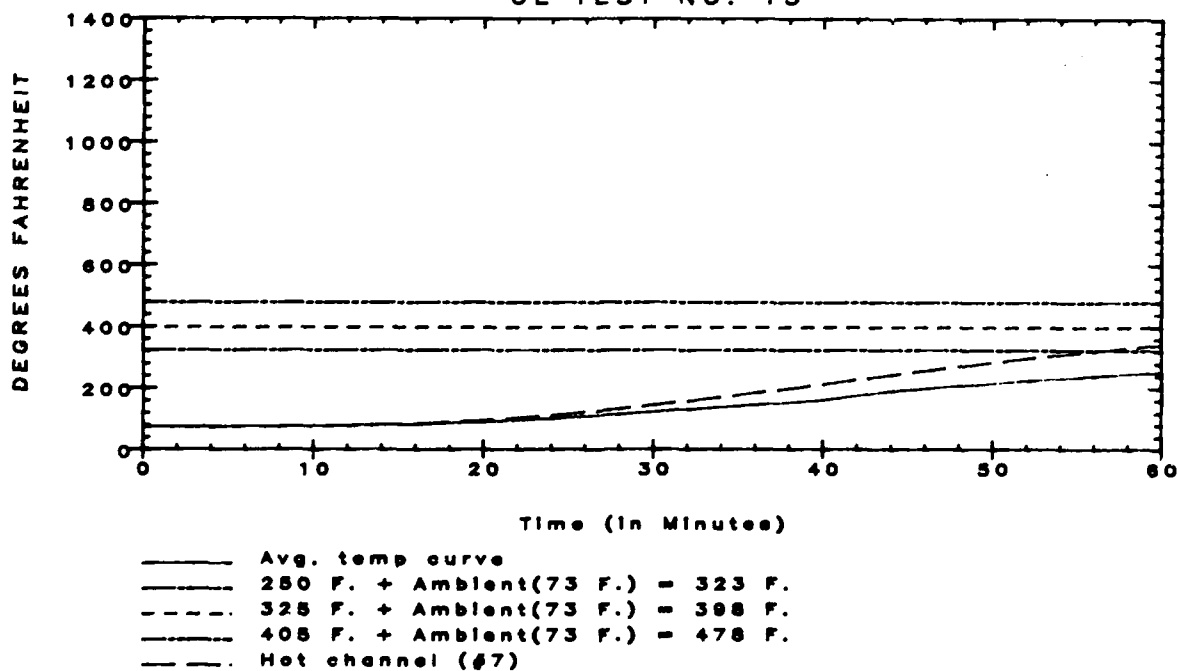
FILE USNC142
 ILL. 23A

U.S. COAST GUARD
 UL Test No. 15 - D10/A60E
 86NK8673/USNC142
 6-13-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 | 13 |
|------------|-------|-------|-------|-------|-------|
| TIME | | | | | |
| 0: 0 | 74.2 | 74.3 | 74.3 | 74.4 | 74.3 |
| 4: 0 | 74.4 | 74.8 | 74.8 | 75.6 | 75.8 |
| 8: 0 | 75.6 | 77.1 | 77.2 | 77.8 | 78.7 |
| 12: 0 | 78.0 | 81.3 | 81.6 | 84.0 | 83.4 |
| 16: 0 | 83.9 | 86.7 | 87.4 | 86.6 | 89.7 |
| 20: 0 | 93.2 | 95.8 | 96.1 | 93.4 | 98.6 |
| 24: 0 | 107.6 | 109.6 | 110.7 | 105.8 | 113.0 |
| 28: 0 | 127.5 | 128.6 | 128.9 | 121.6 | 129.7 |
| 32: 0 | 149.9 | 147.3 | 149.2 | 137.4 | 145.8 |
| 36: 0 | 173.6 | 162.2 | 161.8 | 151.2 | 159.1 |
| 40: 0 | 198.9 | 179.3 | 179.2 | 162.5 | 173.9 |
| 44: 0 | 226.4 | 196.8 | 198.1 | 175.7 | 188.6 |
| 48: 0 | 252.3 | 212.9 | 215.4 | 188.7 | 203.1 |
| 52: 0 | 275.9 | 226.8 | 230.2 | 201.2 | 215.8 |
| 56: 0 | 296.8 | 239.7 | 243.2 | 212.7 | 227.0 |
| 60: 0 | 314.8 | 251.5 | 254.0 | 223.1 | 236.5 |

SAMPLE D10/A60E
 UL TEST NO. 15



T E S T R E C O R D D10/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D10/A60U and as shown in ILL. 24.

The fire and hose stream tests were conducted on June 23, 1986 and identified by UL as Test No. 30.

RESULTS

Observations During Fire Test - All observations referenced to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 23 | The steel plate along with the insulation bowed downward. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 25.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 26 through 26B.

HOSE STREAM TEST:

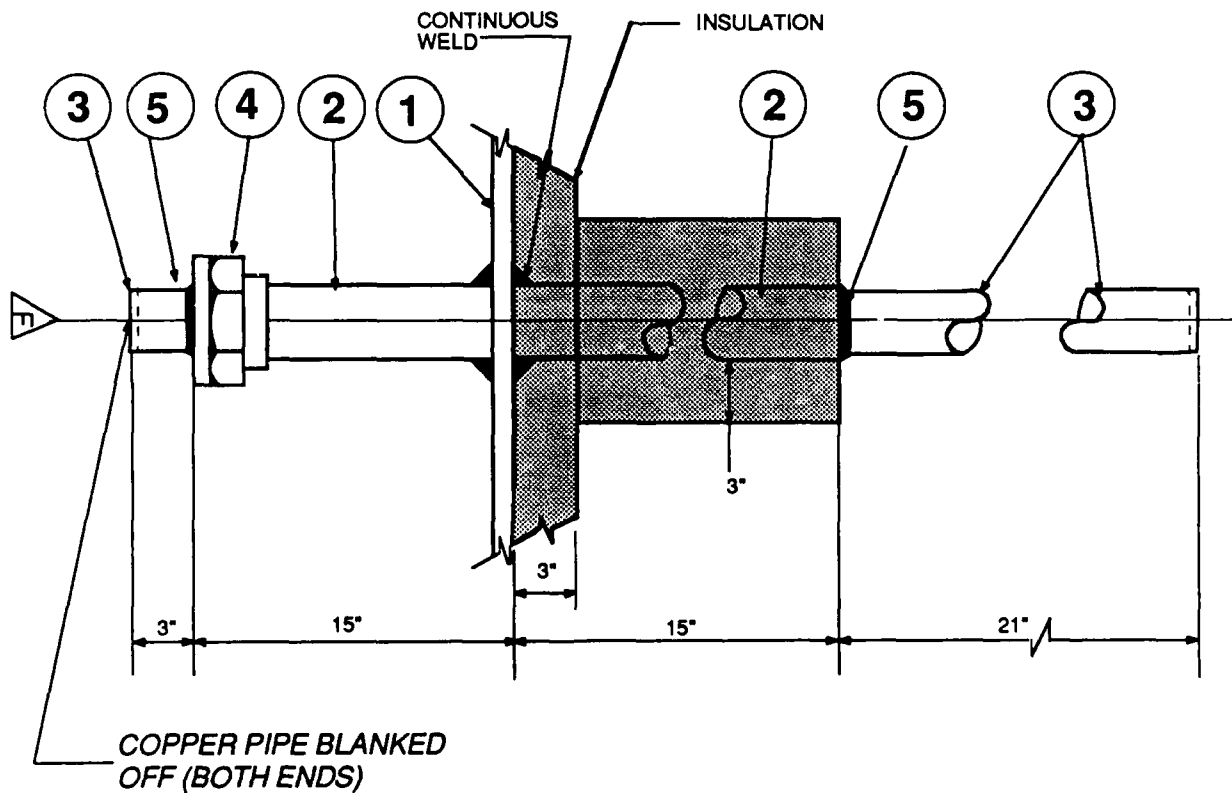
The copper pipe was forced approximately 1 in. forward from the initial force of the hose stream. No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D10/A60U
UL TEST NO. 30

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3-1/2" NOMINAL
DIA. SCHEDULE 40.
- ③ REGULAR COPPER PIPE, 3" NOMINAL DIA.
- ④ BRASS TERMINAL TUBE "KONDU" TYPE V-312 FP,
WITH PILOT HOLE, DRILLED TO SUIT COPPER PIPE.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-10A
COPPER PIPE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE
(R&DC GRAPHIC 8)

USNC 142
ILL. 24

SAMPLE D10/A60U
TEST DATE JUNE 23, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 1 in. above interface of steel and copper pipe. |
| 3 | On penetrant, 6 in. above steel plate. |
| 4 | On penetrant, 12 in. above steel plate. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate insulation, 3 in. from penetrant. |
| 8 | On steel plate insulation, 1 in. from penetrant insulation. |
| 9 | On steel plate insulation seam, 1 in. from penetrant insulation. |
| 10 | On steel plate insulation, 6 in. from penetrant. |
| 11 | On steel plate insulation seam, 6 in. from penetrant. |
| 12 | On steel plate insulation, 12 in. from penetrant. |
| 13 | On steel plate insulation seam, 12 in. from penetrant. |

Note: There is a 3 in. difference in location on Thermocouple Nos. 7, 8 and 9 due to a decision made by the USCG and the CCG after testing had started. For Tests D10/A60E and D10/AO, Thermocouples 7, 8 and 9 are symmetrically located. For D10/A60U they are 3 in. further from the penetrant.

USNC142
ILL. 25

U.S. COAST GUARD
 UL Test No. 30 - D10/A60U
 86NK8673/USNC142
 6-23-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 86.0 | 85.0 | 86.8 | 86.7 |
| 4: 0 | 88.1 | 89.7 | 87.3 | 86.0 |
| 8: 0 | 89.7 | 107.9 | 88.5 | 87.0 |
| 12: 0 | 91.5 | 149.9 | 90.4 | 89.8 |
| 16: 0 | 93.6 | 206.6 | 91.0 | 90.0 |
| 20: 0 | 98.7 | 250.5 | 94.1 | 92.2 |
| 24: 0 | 116.5 | 296.2 | 101.4 | 96.3 |
| 28: 0 | 149.0 | 336.7 | 112.7 | 102.2 |
| 32: 0 | 191.7 | 373.6 | 125.3 | 109.5 |
| 36: 0 | 230.2 | 404.2 | 134.6 | 114.4 |
| 40: 0 | 267.1 | 428.1 | 146.2 | 120.7 |
| 44: 0 | 298.1 | 453.2 | 157.8 | 126.1 |
| 48: 0 | 322.5 | 478.7 | 170.1 | 132.0 |
| 52: 0 | 338.9 | 499.2 | 182.6 | 137.1 |
| 56: 0 | 352.6 | 519.4 | 195.7 | 143.0 |
| 60: 0 | 365.6 | 538.8 | 211.9 | 150.2 |

FILE USNC142
 ILL. 26

U.S. COAST GUARD
 UL Test No. 30 - D10/A60U
 86NK8673/USNC142
 6-23-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 85.0 | 84.6 | 92.5 | 89.9 |
| 4: 0 | 90.5 | 84.5 | 92.8 | 91.9 |
| 8: 0 | 103.6 | 84.4 | 95.6 | 93.3 |
| 12: 0 | 138.9 | 85.9 | 98.4 | 96.7 |
| 16: 0 | 189.6 | 85.0 | 111.3 | 134.2 |
| 20: 0 | 229.0 | 88.3 | 167.7 | 243.8 |
| 24: 0 | 270.3 | 85.5 | 308.5 | 395.3 |
| 28: 0 | 308.9 | 85.8 | 493.1 | 479.7 |
| 32: 0 | 343.2 | 86.9 | 618.7 | 521.8 |
| 36: 0 | 372.6 | 85.9 | 681.5 | 553.4 |
| 40: 0 | 393.0 | 287.1 | 715.8 | 575.4 |
| 44: 0 | 415.8 | 302.8 | 741.1 | 590.9 |
| 48: 0 | 440.1 | 320.6 | 760.4 | 603.4 |
| 52: 0 | 460.3 | 334.8 | 775.2 | 612.9 |
| 56: 0 | 477.1 | 346.8 | 787.1 | 620.6 |
| 60: 0 | 478.8 | 356.7 | 804.3 | 629.9 |

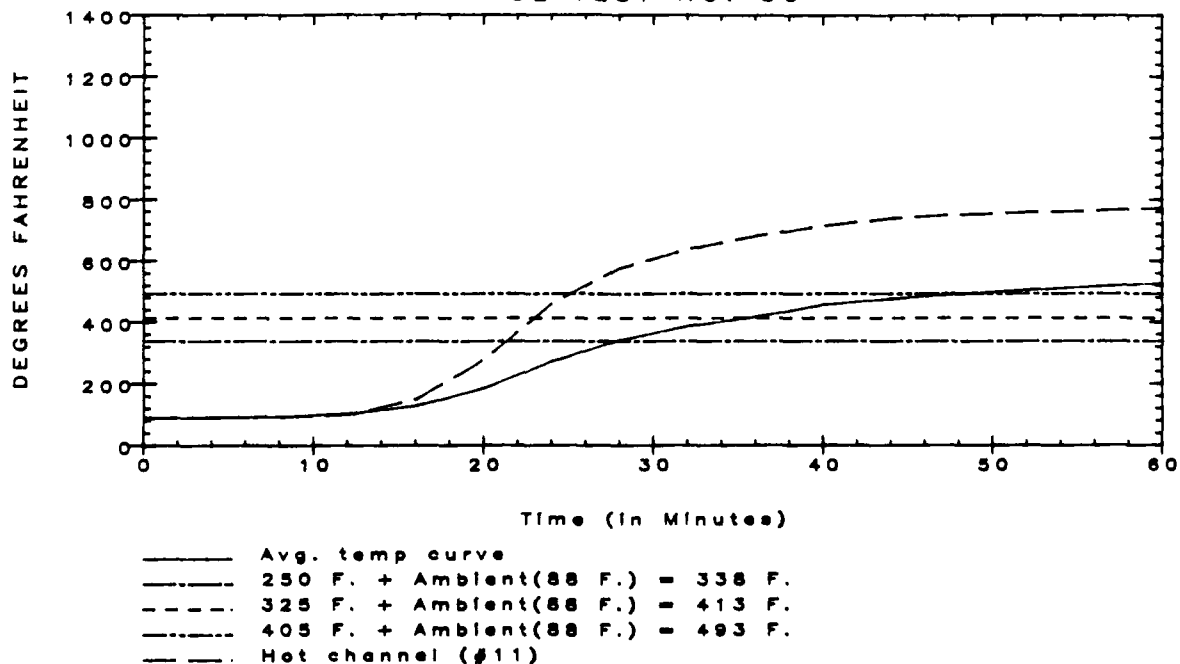
FILE USNC142
 ILL. 26A

U.S. COAST GUARD
 UL Test No. 30 - D10/A60U
 86NK8673/USNC142
 6-23-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 | 13 |
|------------|-------|-------|-------|-------|-------|
| TIME | | | | | |
| 0: 0 | 89.6 | 89.6 | 89.7 | 88.6 | 88.4 |
| 4: 0 | 92.2 | 92.7 | 90.3 | 90.3 | 92.6 |
| 8: 0 | 94.6 | 94.1 | 93.0 | 93.1 | 101.9 |
| 12: 0 | 97.7 | 95.6 | 99.8 | 99.2 | 115.4 |
| 16: 0 | 116.0 | 122.7 | 149.1 | 149.1 | 144.0 |
| 20: 0 | 181.7 | 221.0 | 276.3 | 276.6 | 196.6 |
| 24: 0 | 326.7 | 374.2 | 460.8 | 435.9 | 292.1 |
| 28: 0 | 477.7 | 460.4 | 577.4 | 520.6 | 382.1 |
| 32: 0 | 571.0 | 501.4 | 638.6 | 563.8 | 438.8 |
| 36: 0 | 637.9 | 527.7 | 680.7 | 592.3 | 471.9 |
| 40: 0 | 673.5 | 548.3 | 714.7 | 615.0 | 493.1 |
| 44: 0 | 695.7 | 565.4 | 738.4 | 634.4 | 510.0 |
| 48: 0 | 708.8 | 574.3 | 751.3 | 647.9 | 522.4 |
| 52: 0 | 720.3 | 583.5 | 759.0 | 660.9 | 533.3 |
| 56: 0 | 728.6 | 591.0 | 764.6 | 670.4 | 541.2 |
| 60: 0 | 738.7 | 599.8 | 773.2 | 680.1 | 548.5 |

SAMPLE D10/A60U
 UL TEST NO. 30



T E S T R E C O R D D10/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D10/A0 and as shown in ILL. 27.

The fire and hose stream tests were conducted on June 3, 1986 and identified by UL as Test No. 1.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 10 | The steel plate was blackish in color. |
| 27 | The RTV sealant at the interface of the copper and steel pipes was puffing outward. |
| 42 | The steel plate was glowing red. |
| 49 | Smoke issued from the interface of the copper and steel pipes. |
| 60 | Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 28.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 29 through 29B.

HOSE STREAM TEST:

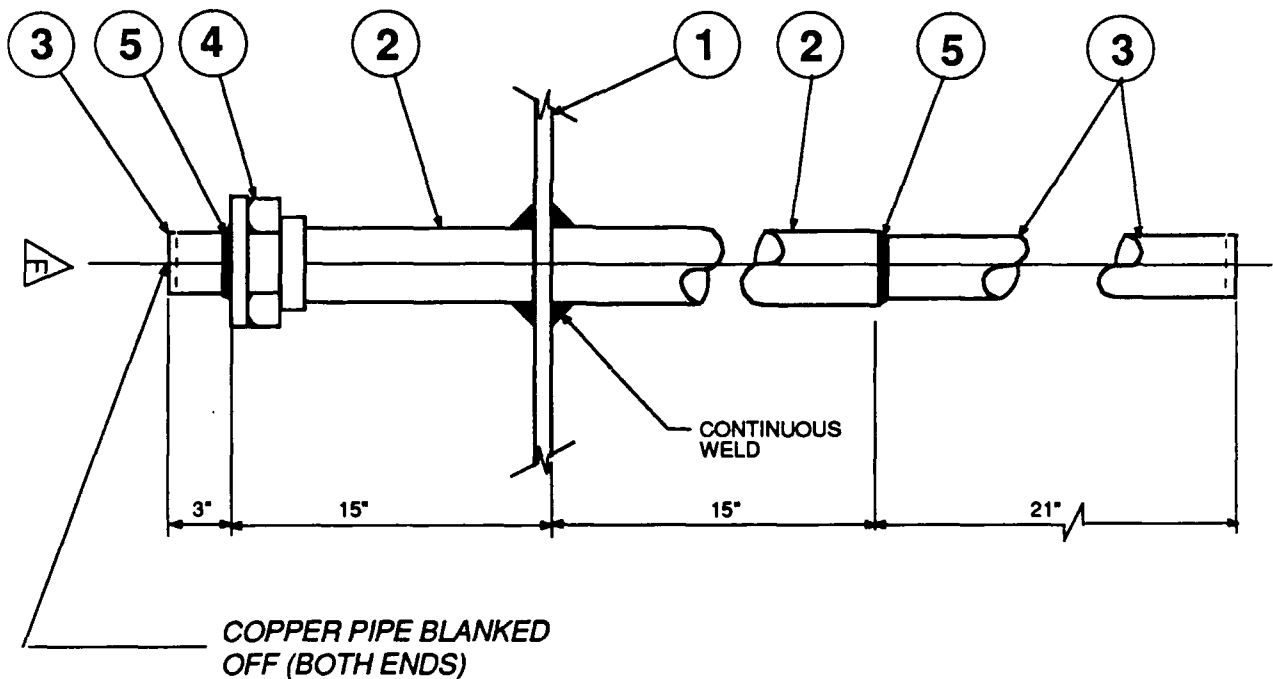
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D10/AO
UL TEST NO. 1

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3-1/2" NOMINAL
DIA. SCHEDULE 40.
- ③ REGULAR COPPER PIPE, 3" NOMINAL DIA.
- ④ BRASS TERMINAL TUBE "KONDU" TYPE V-312 FP,
WITH PILOT HOLE, DRILLED TO SUIT COPPER PIPE.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-10A
COPPER PIPE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE

(R&DC GRAPHIC 7)

USNC 142
ILL. 27

SAMPLE D10/A0
TEST DATE JUNE 3, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 1 in. above interface of steel and copper pipes. |
| 3 | On penetrant, 6 in. above steel plate. |
| 4 | On penetrant, 12 in. above steel plate. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On interface of steel plate and penetrant. |
| 8 | On steel plate, 1 in. from penetrant. |
| 9 | On steel plate, 1 in. from penetrant. |
| 10 | On steel plate, 6 in. from penetrant. |
| 11 | On steel plate, 6 in. from penetrant. |
| 12 | On steel plate, 12 in. from penetrant. |

USNC142
ILL. 28

U.S. COAST GUARD
 UL Test No. 1 - D10/A0
 86NK8673/USNC142
 6-3-86

| Temperature Degrees F | | | | |
|-----------------------|-------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 72.2 | 72.2 | 72.2 | 72.2 |
| 4: 0 | 75.7 | 88.3 | 79.2 | 74.8 |
| 8: 0 | 88.3 | 145.0 | 98.7 | 88.5 |
| 12: 0 | 130.9 | 247.7 | 146.5 | 127.8 |
| 16: 0 | 197.4 | 352.8 | 206.0 | 184.2 |
| 20: 0 | 277.3 | 441.3 | 263.1 | 251.0 |
| 24: 0 | 349.7 | 508.8 | 315.9 | 314.7 |
| 28: 0 | 411.3 | 562.5 | 365.4 | 370.4 |
| 32: 0 | 459.0 | 610.1 | 411.3 | 413.1 |
| 36: 0 | 496.3 | 645.6 | 447.6 | 445.0 |
| 40: 0 | 527.9 | 675.0 | 475.7 | 472.9 |
| 44: 0 | 554.9 | 697.6 | 498.5 | 495.8 |
| 48: 0 | 577.6 | 714.7 | 515.8 | 516.3 |
| 52: 0 | 595.8 | 731.9 | 531.5 | 531.8 |
| 56: 0 | 613.5 | 747.3 | 546.0 | 549.5 |
| 60: 0 | 627.2 | 758.2 | 557.1 | 562.0 |

FILE USNC142
 ILL. 29

U.S. COAST GUARD
 UL Test No. 1 - D10/A0
 86NK8673/USNC142
 6-3-86

Temperature Degrees F

| CHAN(NOS.) | 5 | 6 | 7 | 8 |
|------------|-------|--------|--------|--------|
| TIME | | | | |
| 0: 0 | 72.2 | 70.5 | 70.5 | 71.6 |
| 4: 0 | 76.2 | 282.2 | 372.7 | 370.6 |
| 8: 0 | 87.2 | 543.6 | 714.1 | 729.4 |
| 12: 0 | 113.4 | 778.7 | 936.8 | 957.8 |
| 16: 0 | 151.0 | 923.1 | 1060.2 | 1078.2 |
| 20: 0 | 196.9 | 995.3 | 1116.8 | 1131.7 |
| 24: 0 | 242.0 | 1046.2 | 1159.4 | 1178.4 |
| 28: 0 | 286.7 | 1089.4 | 1197.0 | 1219.1 |
| 32: 0 | 322.5 | 1132.7 | 1239.8 | 1264.2 |
| 36: 0 | 351.1 | 1163.9 | 1268.5 | 1294.3 |
| 40: 0 | 376.4 | 1191.9 | 1299.4 | 1320.9 |
| 44: 0 | 397.7 | 1214.7 | 1321.0 | 1344.8 |
| 48: 0 | 416.5 | 1235.2 | 1342.4 | 1364.9 |
| 52: 0 | 429.8 | 1258.2 | 1369.5 | 1391.7 |
| 56: 0 | 447.1 | 1276.2 | 1388.9 | 1407.3 |
| 60: 0 | 458.2 | 1288.9 | 1400.6 | 1416.8 |

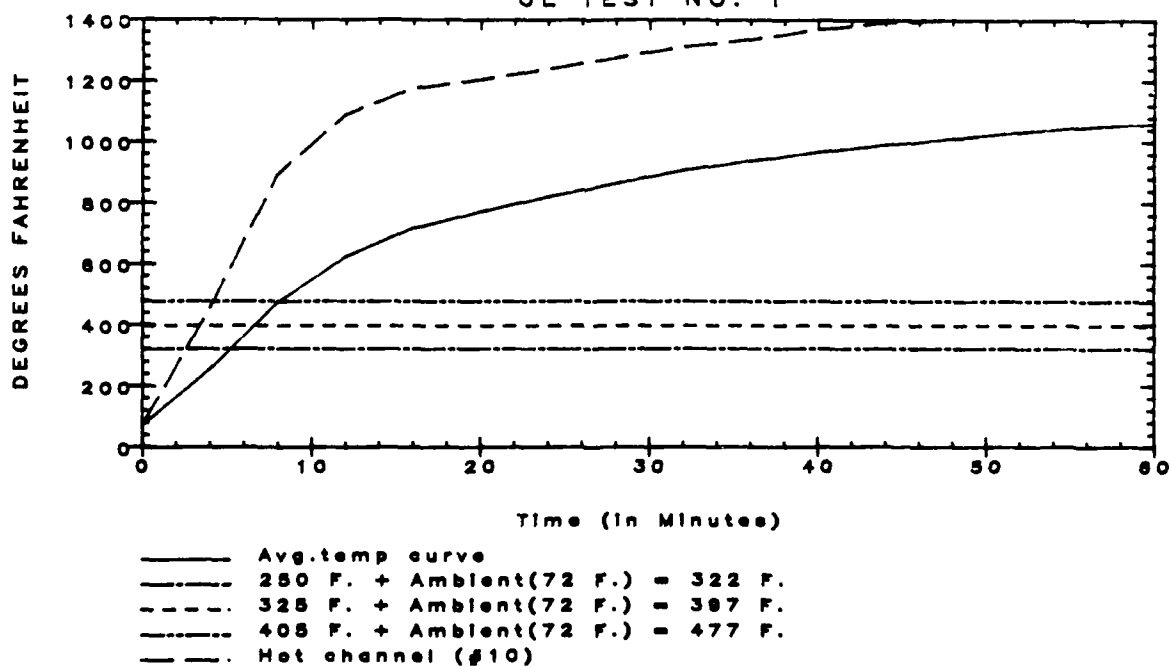
FILE USNC142
 ILL. 29A

U.S. COAST GUARD
 UL Test No. 1 - D10/A0
 86NK8673/USNC142
 6-3-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|--------|--------|--------|--------|
| TIME | | | | |
| 0: 0 | 71.7 | 71.7 | 71.7 | 71.8 |
| 4: 0 | 428.6 | 455.2 | 352.9 | 410.0 |
| 8: 0 | 815.1 | 894.4 | 674.6 | 810.9 |
| 12: 0 | 1018.9 | 1088.4 | 896.1 | 1036.2 |
| 16: 0 | 1120.2 | 1175.3 | 1018.0 | 1131.5 |
| 20: 0 | 1157.1 | 1204.7 | 1061.1 | 1165.9 |
| 24: 0 | 1192.3 | 1239.9 | 1098.7 | 1200.9 |
| 28: 0 | 1227.7 | 1276.0 | 1134.8 | 1240.6 |
| 32: 0 | 1272.4 | 1311.6 | 1176.2 | 1278.0 |
| 36: 0 | 1300.2 | 1336.9 | 1202.1 | 1304.3 |
| 40: 0 | 1330.9 | 1369.4 | 1234.9 | 1333.2 |
| 44: 0 | 1355.8 | 1393.4 | 1257.4 | 1353.3 |
| 48: 0 | 1382.5 | 1412.0 | 1280.9 | 1372.1 |
| 52: 0 | 1413.8 | 1438.5 | 1305.8 | 1396.3 |
| 56: 0 | 1433.5 | 1450.1 | 1339.4 | 1408.4 |
| 60: 0 | 1444.3 | 1456.5 | 1346.2 | 1412.6 |

SAMPLE D10/A0
 UL TEST NO. 1



T E S T R E C O R D D11/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D11/A60U and as shown in ILL. 30.

The fire and hose stream tests were conducted on June 20, 1986 and identified by UL as Test No. 28.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 20 | The steel plate along with the insulation was bowing downward. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 31.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 32 through 32B.

HOSE STREAM TEST:

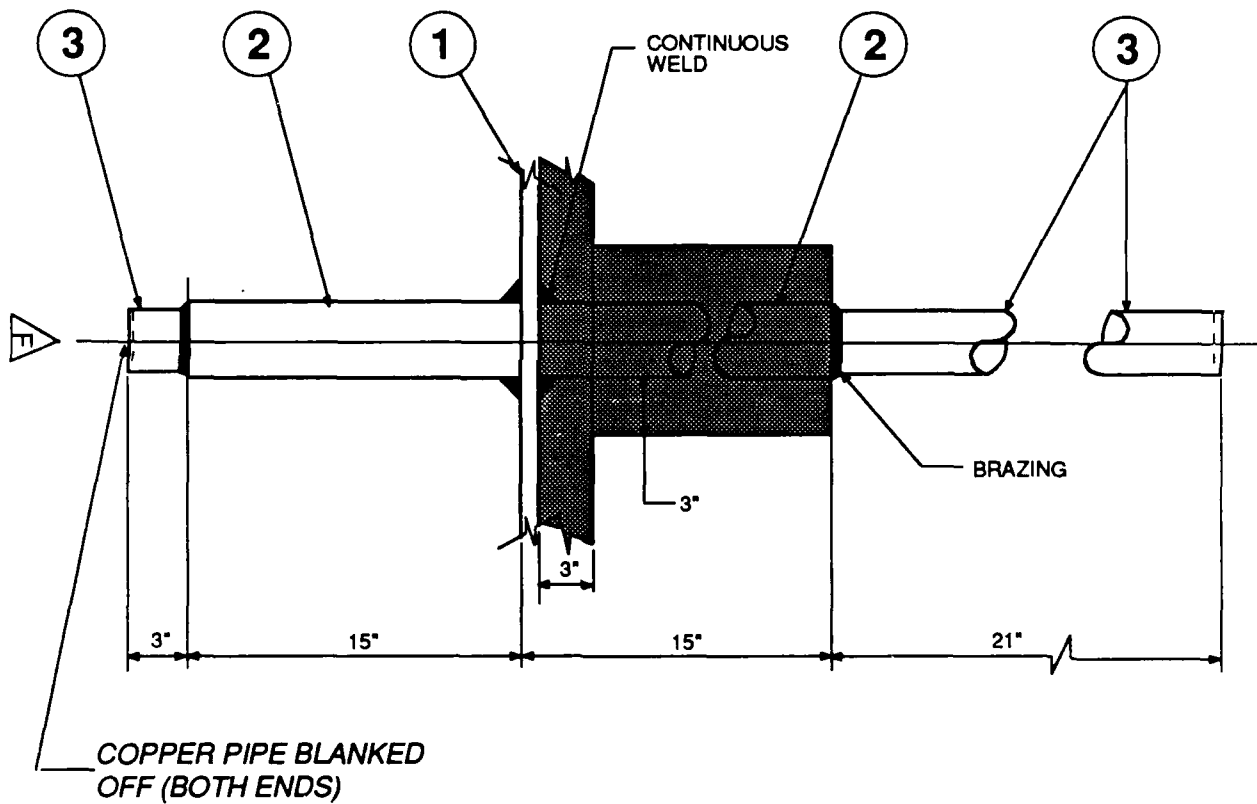
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D11/A60U
UL TEST NO. 28

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3-1/2" NOMINAL
DIA. SCHEDULE 40.
- ③ REGULAR COPPER PIPE, 3" NOMINAL DIA.



TEST SAMPLE NO. D-11A
COPPER PIPE WITH
STEEL SPIGOT
(R&DC GRAPHIC 10)

USNC 142
ILL. 30

SAMPLE D11/A60U
TEST DATE JUNE 20, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at interface of steel pipe and copper pipe. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate insulation, at interface of penetrant insulation. |
| 8 | On steel plate insulation, 6 in. from penetrant. |
| 9 | On steel plate insulation seam, 6 in. from penetrant. |
| 10 | On steel plate insulation, 12 in. from penetrant. |
| 11 | On steel plate insulation seam, 12 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 31

U.S. COAST GUARD
 UL Test No. 28 - D11/A60U
 86NK8673/USNC142
 6-20-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 73.8 | 73.9 | 74.3 | 74.8 |
| 4: 0 | 74.7 | 74.5 | 74.7 | 74.4 |
| 8: 0 | 75.8 | 75.2 | 75.3 | 76.4 |
| 12: 0 | 78.7 | 76.3 | 76.1 | 78.7 |
| 16: 0 | 83.3 | 77.5 | 77.5 | 83.4 |
| 20: 0 | 86.9 | 79.3 | 78.6 | 89.9 |
| 24: 0 | 94.6 | 83.4 | 82.3 | 97.7 |
| 28: 0 | 129.2 | 92.5 | 88.8 | 106.9 |
| 32: 0 | 193.1 | 102.9 | 95.7 | 115.7 |
| 36: 0 | 255.1 | 115.4 | 102.5 | 125.1 |
| 40: 0 | 304.4 | 127.2 | 109.0 | 133.3 |
| 44: 0 | 341.3 | 141.4 | 115.0 | 144.4 |
| 48: 0 | 368.7 | 157.4 | 121.3 | 153.4 |
| 52: 0 | 388.8 | 174.9 | 128.3 | 160.5 |
| 56: 0 | 404.0 | 192.8 | 136.5 | 168.9 |
| 60: 0 | 416.4 | 212.9 | 143.2 | 179.1 |

FILE USNC142
 ILL. 32

U.S. COAST GUARD
 UL Test No. 28 - D11/A60U
 86NK8673/USNC142
 6-20-86

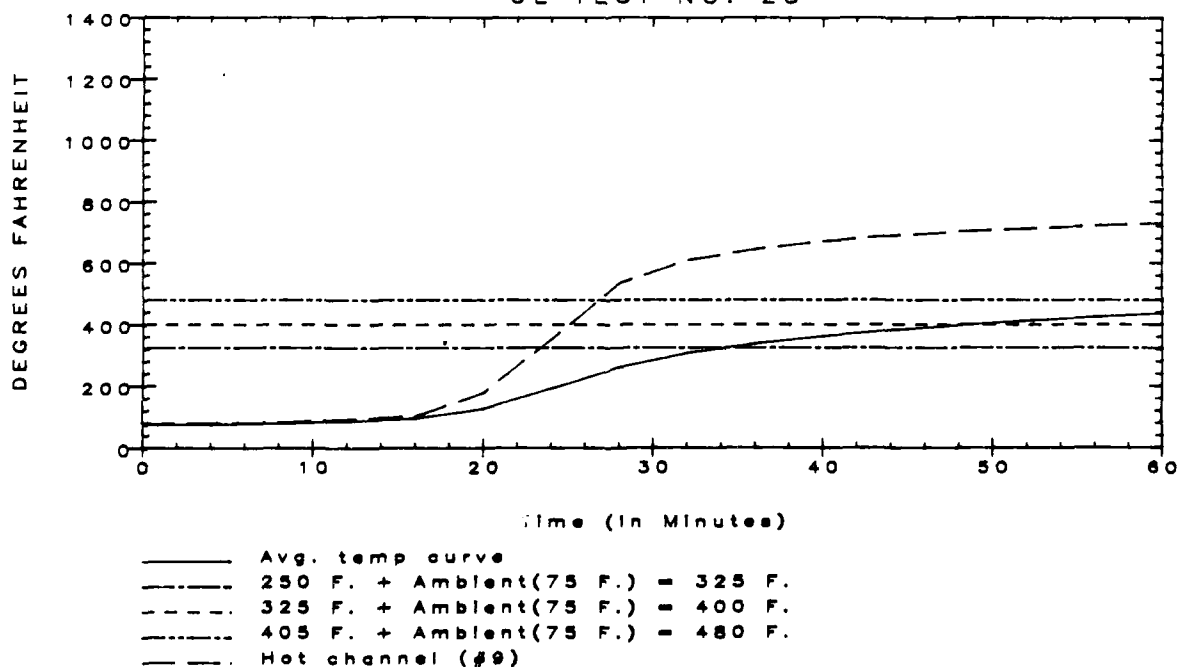
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 72.6 | 71.6 | 75.2 | 76.5 |
| 4: 0 | 74.3 | 72.6 | 76.3 | 77.2 |
| 8: 0 | 90.8 | 77.0 | 79.0 | 78.8 |
| 12: 0 | 104.0 | 87.6 | 90.2 | 86.8 |
| 16: 0 | 142.5 | 107.7 | 95.0 | 92.9 |
| 20: 0 | 189.3 | 135.6 | 148.3 | 149.1 |
| 24: 0 | 235.0 | 166.4 | 277.9 | 299.3 |
| 28: 0 | 274.4 | 195.6 | 434.3 | 424.4 |
| 32: 0 | 309.6 | 221.9 | 549.5 | 466.4 |
| 36: 0 | 343.0 | 246.8 | 616.1 | 487.0 |
| 40: 0 | 376.1 | 270.4 | 652.4 | 503.0 |
| 44: 0 | 407.2 | 293.7 | 677.2 | 517.1 |
| 48: 0 | 436.1 | 315.3 | 696.0 | 524.3 |
| 52: 0 | 462.9 | 334.1 | 711.7 | 529.4 |
| 56: 0 | 485.8 | 351.0 | 727.0 | 532.8 |
| 60: 0 | 506.2 | 366.4 | 739.6 | 540.4 |

FILE USNC142
 ILL. 32A

U.S. COAST GUARD
 UL Test No. 28 - D11/A60U
 86NK8673/USNC142
 6-20-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 78.6 | 77.5 | 76.6 | 73.5 |
| 4: 0 | 79.4 | 78.5 | 77.7 | 74.1 |
| 8: 0 | 81.8 | 80.1 | 81.8 | 75.5 |
| 12: 0 | 92.7 | 88.3 | 92.8 | 81.9 |
| 16: 0 | 101.8 | 92.4 | 103.0 | 91.1 |
| 20: 0 | 178.9 | 128.4 | 157.8 | 103.9 |
| 24: 0 | 352.4 | 228.3 | 269.6 | 120.5 |
| 28: 0 | 534.4 | 316.8 | 403.8 | 139.3 |
| 32: 0 | 609.0 | 363.4 | 504.4 | 158.2 |
| 36: 0 | 644.6 | 391.4 | 560.8 | 178.5 |
| 40: 0 | 670.4 | 410.2 | 595.7 | 197.7 |
| 44: 0 | 689.9 | 427.1 | 620.0 | 215.4 |
| 48: 0 | 703.3 | 440.9 | 636.3 | 232.2 |
| 52: 0 | 713.5 | 450.8 | 649.5 | 247.6 |
| 56: 0 | 722.4 | 463.5 | 662.1 | 262.1 |
| 60: 0 | 730.7 | 472.6 | 671.2 | 274.8 |

SAMPLE D11/A60U
 UL TEST NO. 28



T E S T R E C O R D D14/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D14/A60E and as shown in ILL. 33.

The fire and hose stream tests were conducted on June 5, 1986 and identified by UL as Test No. 3.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 38 | The steel plate was bowing slightly downward. |
| 40 | The intensity of the smoke increased. |
| 60 | The PVC pipe cover on the exposed side was consumed. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 34.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 35 through 35B.

HOSE STREAM TEST:

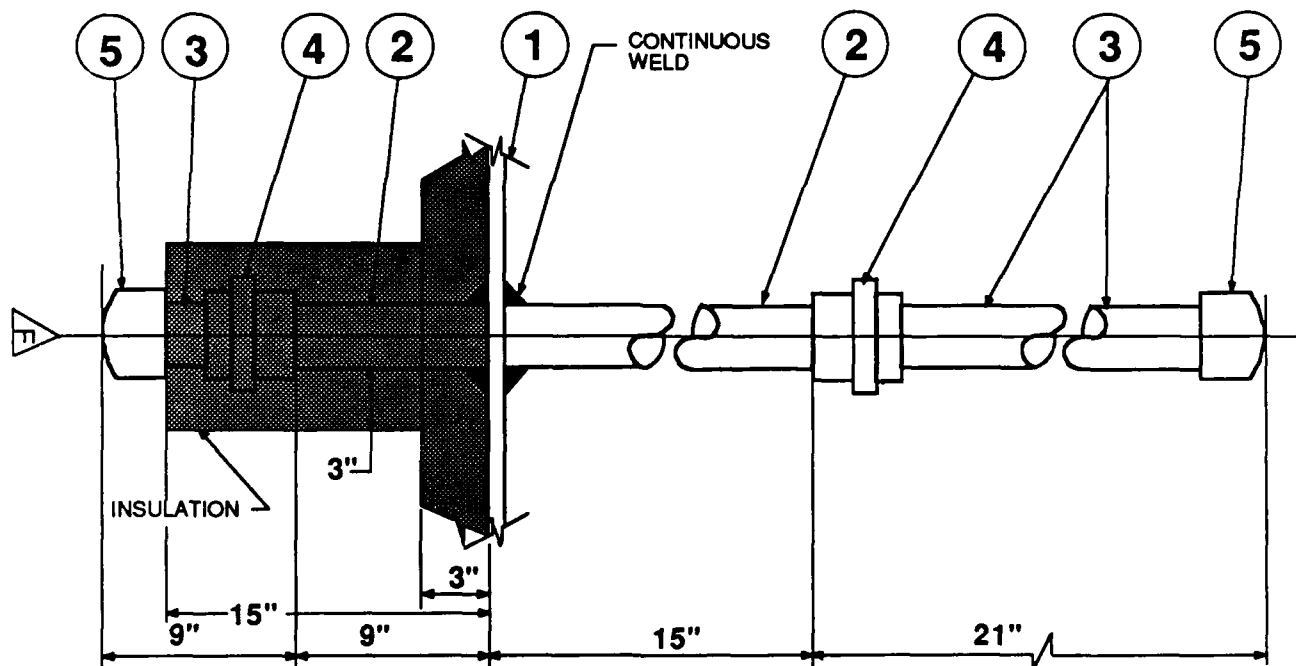
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D14/A60E
UL TEST NO. 3

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3" NOMINAL
DIA. SCHEDULE 40.
- ③ PVC (PLASTIC) PIPE 3" NOMINAL DIA.
SCHEDULE 40, ASTM D-1784/1785.
- ④ PVC (PLASTIC) UNION, FEMALE THREAD/SOCKET,
3" NOMINAL PIPE DIAMETER.
- ⑤ PVC (PLASTIC) CAP, 3" NOMINAL PIPE DIAMETER.



TEST SAMPLE NO. D-14A
PVC (PLASTIC) PIPE
WITH STEEL SPIGOT
(R&DC GRAPHIC 13)

USNC 142
ILL. 33

SAMPLE D14/A60E
TEST DATE JUNE 5, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On the penetrant, 4 in. above steel plate. |
| 2 | On penetrant, at interface of steel pipe and union. |
| 3 | On the surface of penetrant PVC union - (18 in. above steel plate). |
| 4 | On penetrant, at interface of PVC union and PVC pipe. |
| 5 | On penetrant, 12 in. above steel plate. |
| 6 | On top of penetrant. |
| 7 | On penetrant, 24 in. above steel plate. |
| 8 | On steel plate over insulation, 3 in. from penetrant. |
| 9 | On steel plate over insulation, 6 in. from penetrant. |
| 10 | On steel plate over insulation seam, 6 in. from penetrant. |
| 11 | On steel plate over insulation, 12 in. from penetrant. |
| 12 | On steel plate over insulation seam, 12 in. from penetrant. |

USNC142
ILL. 34

U.S. COAST GUARD
 UL Test No. 3 - D14/A60E
 86NK8673/USNC142
 6-5-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|------|------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 71.0 | 71.4 | 72.3 | 70.4 |
| 4: 0 | 72.2 | 71.6 | 70.3 | 71.6 |
| 8: 0 | 73.3 | 72.4 | 70.5 | 70.7 |
| 12: 0 | 75.5 | 73.2 | 70.9 | 70.9 |
| 16: 0 | 78.9 | 74.1 | 71.3 | 71.1 |
| 20: 0 | 84.3 | 75.8 | 71.7 | 71.3 |
| 24: 0 | 93.8 | 79.1 | 72.3 | 71.7 |
| 28: 0 | 102.0 | 82.5 | 73.0 | 72.2 |
| 32: 0 | 111.1 | 86.3 | 73.9 | 73.2 |
| 36: 0 | 119.4 | 90.6 | 75.0 | 75.5 |
| 40: 0 | 128.7 | 94.2 | 77.6 | 75.8 |
| 44: 0 | 136.6 | 98.9 | 77.9 | 77.4 |
| 48: 0 | 144.9 | 103.3 | 79.6 | 79.2 |
| 52: 0 | 153.4 | 107.2 | 81.5 | 81.2 |
| 56: 0 | 162.5 | 111.1 | 83.7 | 82.4 |
| 60: 0 | 173.0 | 115.3 | 85.9 | 85.1 |

FILE USNC142
 ILL. 35

U.S. COAST GUARD
 UL Test No. 3 - D14/A60E
 86NK8673/USNC142
 6-5-86

| | Temperature Degrees F | | | |
|------------|-----------------------|------|------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 71.6 | 70.8 | 70.2 | 72.2 |
| 4: 0 | 70.7 | 71.8 | 71.1 | 72.4 |
| 8: 0 | 71.5 | 70.8 | 71.3 | 74.2 |
| 12: 0 | 72.9 | 71.0 | 73.1 | 78.4 |
| 16: 0 | 74.8 | 71.7 | 73.7 | 84.2 |
| 20: 0 | 78.4 | 71.7 | 74.5 | 93.5 |
| 24: 0 | 82.7 | 72.2 | 74.2 | 106.5 |
| 28: 0 | 87.5 | 73.2 | 76.3 | 124.2 |
| 32: 0 | 92.6 | 73.4 | 77.6 | 142.3 |
| 36: 0 | 96.7 | 74.0 | 78.0 | 158.3 |
| 40: 0 | 102.6 | 74.7 | 79.2 | 174.0 |
| 44: 0 | 107.8 | 76.6 | 80.6 | 194.0 |
| 48: 0 | 112.4 | 76.2 | 84.7 | 212.0 |
| 52: 0 | 117.3 | 77.0 | 86.1 | 227.5 |
| 56: 0 | 121.1 | 77.9 | 91.3 | 241.6 |
| 60: 0 | 125.8 | 78.9 | 94.0 | 254.0 |

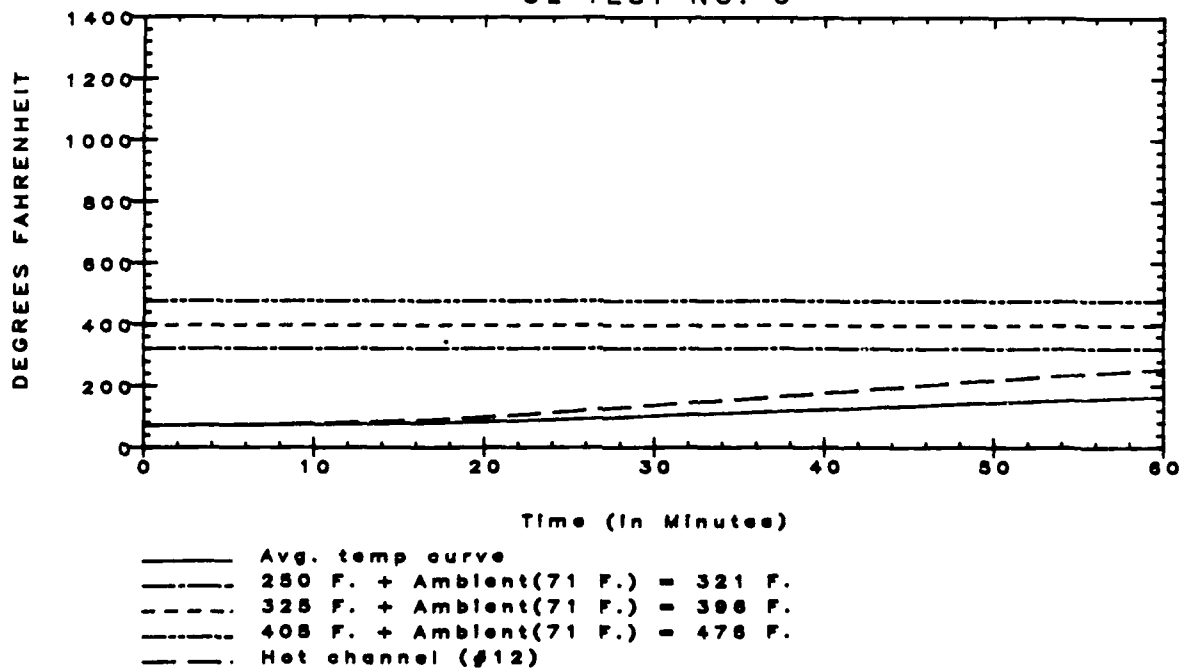
FILE USNC142
 ILL. 35A

U.S. COAST GUARD
 UL Test No. 3 - D14/A60E
 86NK8673/USNC142
 6-5-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 71.1 | 71.0 | 71.0 | 71.7 |
| 4: 0 | 71.4 | 72.4 | 72.7 | 72.5 |
| 8: 0 | 74.1 | 74.7 | 74.6 | 75.3 |
| 12: 0 | 77.7 | 78.0 | 78.2 | 80.8 |
| 16: 0 | 82.5 | 84.9 | 83.3 | 87.6 |
| 20: 0 | 89.6 | 94.3 | 91.5 | 97.8 |
| 24: 0 | 100.4 | 108.9 | 100.5 | 113.1 |
| 28: 0 | 116.6 | 126.2 | 114.7 | 130.4 |
| 32: 0 | 135.6 | 143.1 | 131.1 | 146.0 |
| 36: 0 | 151.8 | 157.0 | 147.3 | 159.8 |
| 40: 0 | 164.9 | 173.7 | 160.1 | 177.5 |
| 44: 0 | 182.0 | 191.1 | 174.8 | 194.5 |
| 48: 0 | 198.0 | 207.9 | 190.6 | 211.3 |
| 52: 0 | 212.5 | 222.0 | 205.2 | 226.8 |
| 56: 0 | 229.8 | 234.9 | 218.4 | 241.8 |
| 60: 0 | 237.3 | 246.2 | 230.4 | 254.8 |

SAMPLE D14/A60E
 UL TEST NO. 3



T E S T R E C O R D D14/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D14/A60U and as shown in ILL. 36.

The fire and hose stream tests were conducted on June 4, 1986 and identified by UL as Test No. 2.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Note: The PVC pipe on the unexposed side collapsed when the support wire was removed after the test was terminated.

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 37.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 38 through 38B.

HOSE STREAM TEST:

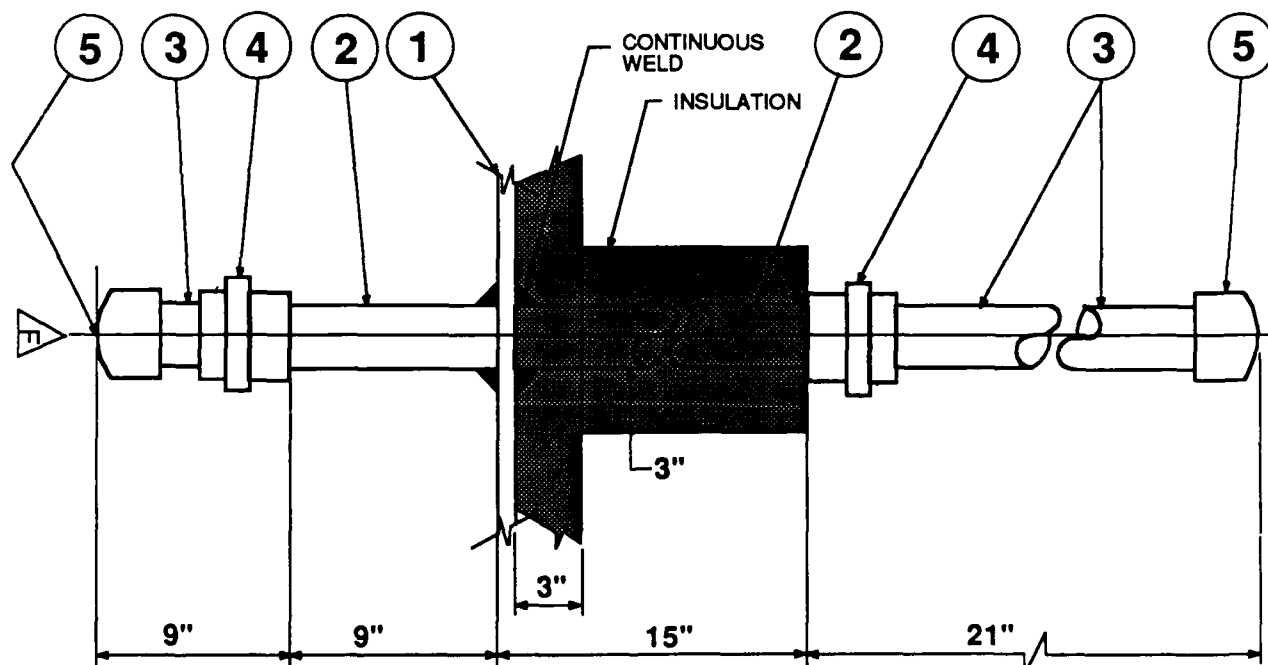
Water passed through an opening that was present due to the PVC pipe on the exposed side being consumed during the fire endurance test, and the PVC pipe on the unexposed side collapsing after the fire endurance test.

Pictorial History - Photographs were taken before, during and after the fire test.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D14/A60U
UL TEST NO. 2

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3" NOMINAL
DIA. SCHEDULE 40.
- ③ PVC (PLASTIC) PIPE 3" NOMINAL DIA.
SCHEDULE 40, ASTM D-1784/1785.
- ④ PVC (PLASTIC) UNION, FEMALE THREAD/SOCKET,
3" NOMINAL PIPE DIAMETER.
- ⑤ PVC (PLASTIC) CAP, 3" NOMINAL PIPE DIAMETER.



TEST SAMPLE NO. D-14A
PVC (PLASTIC) PIPE
WITH STEEL SPIGOT
(R&DC GRAPHIC 14)

USNC 142
ILL. 36

SAMPLE D14/A60U
TEST DATE JUNE 4, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, at interface of steel pipe and union. |
| 3 | On the surface of penetrant PVC union, (18 in. above steel plate). |
| 4 | On penetrant, at interface of PVC union and PVC pipe. |
| 5 | On penetrant, 12 in. above steel plate. |
| 6 | On top of penetrant. |
| 7 | On penetrant, 24 in. above steel plate. |
| 8 | At interface of steel plate insulation and penetrant insulation. |
| 9 | On steel plate insulation, 6 in. from penetrant. |
| 10 | On steel plate insulation seam, 6 in. from penetrant. |
| 11 | On steel plate insulation, 12 in. from penetrant. |
| 12 | On steel plate insulation seam, 12 in. from penetrant. |

USNC142
ILL. 37

U.S. COAST GUARD
 UL Test No. 2 - D14/A60U
 86NK8673/USNC142
 6-4-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 77.0 | 75.6 | 75.9 | 75.7 |
| 4: 0 | 78.9 | 77.3 | 77.0 | 76.6 |
| 8: 0 | 79.5 | 87.1 | 77.0 | 76.8 |
| 12: 0 | 80.6 | 93.7 | 77.4 | 78.6 |
| 16: 0 | 82.3 | 104.1 | 77.9 | 78.4 |
| 20: 0 | 85.8 | 118.1 | 78.8 | 79.7 |
| 24: 0 | 88.6 | 137.2 | 81.3 | 81.5 |
| 28: 0 | 96.5 | 162.9 | 83.1 | 83.7 |
| 32: 0 | 121.6 | 190.8 | 85.4 | 86.2 |
| 36: 0 | 170.6 | 220.5 | 88.6 | 89.2 |
| 40: 0 | 228.5 | 251.8 | 92.5 | 93.8 |
| 44: 0 | 280.7 | 284.9 | 95.5 | 96.5 |
| 48: 0 | 329.8 | 316.8 | 99.4 | 100.7 |
| 52: 0 | 370.3 | 348.8 | 103.9 | 105.3 |
| 56: 0 | 395.0 | 379.9 | 108.5 | 110.0 |
| 60: 0 | 411.0 | 411.6 | 113.3 | 114.9 |

FILE USNC142
 ILL. 38

U.S. COAST GUARD
UL Test No. 2 - D14/A60U
86NK8673/USNC142
6-4-86

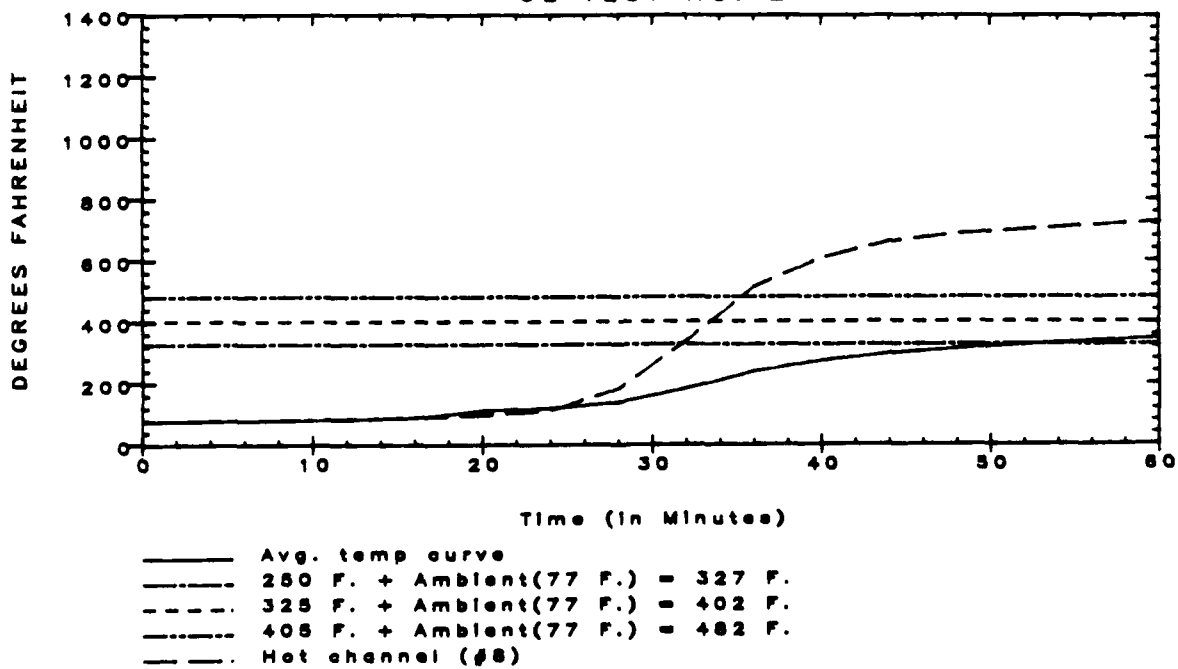
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 76.6 | 76.4 | 76.4 | 77.2 |
| 4: 0 | 79.0 | 77.3 | 79.3 | 79.5 |
| 8: 0 | 78.3 | 78.7 | 81.2 | 81.5 |
| 12: 0 | 78.9 | 80.9 | 82.6 | 85.8 |
| 16: 0 | 80.8 | 83.8 | 86.0 | 91.1 |
| 20: 0 | 82.1 | 88.4 | 91.8 | 98.4 |
| 24: 0 | 83.0 | 92.0 | 96.5 | 114.4 |
| 28: 0 | 87.1 | 97.3 | 101.9 | 184.7 |
| 32: 0 | 90.2 | 101.5 | 106.3 | 338.2 |
| 36: 0 | 98.3 | 106.0 | 110.4 | 514.7 |
| 40: 0 | 107.7 | 111.4 | 114.1 | 608.4 |
| 44: 0 | 119.8 | 117.3 | 117.9 | 662.3 |
| 48: 0 | 119.9 | 123.1 | 122.5 | 687.5 |
| 52: 0 | 126.1 | 128.9 | 127.1 | 702.3 |
| 56: 0 | 130.9 | 134.4 | 132.1 | 714.6 |
| 60: 0 | 136.5 | 139.5 | 137.0 | 728.1 |

FILE USNC142
ILL. 38A

U.S. COAST GUARD
 UL Test No. 2 - D14/A60U
 86NK8673/USNC142
 6-4-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 77.8 | 77.0 | 77.8 | 77.7 |
| 4: 0 | 79.6 | 81.5 | 79.6 | 79.4 |
| 8: 0 | 80.0 | 87.6 | 80.0 | 81.7 |
| 12: 0 | 83.5 | 96.3 | 83.5 | 86.5 |
| 16: 0 | 87.7 | 117.4 | 86.4 | 98.5 |
| 20: 0 | 94.6 | 194.6 | 92.3 | 150.1 |
| 24: 0 | 109.2 | 276.5 | 98.9 | 193.5 |
| 28: 0 | 150.9 | 298.6 | 116.4 | 218.2 |
| 32: 0 | 247.0 | 374.5 | 172.5 | 299.8 |
| 36: 0 | 359.4 | 444.8 | 283.3 | 380.4 |
| 40: 0 | 414.2 | 479.5 | 367.5 | 422.2 |
| 44: 0 | 433.5 | 497.8 | 413.6 | 444.9 |
| 48: 0 | 441.6 | 512.3 | 437.7 | 461.3 |
| 52: 0 | 452.8 | 526.1 | 452.3 | 466.3 |
| 56: 0 | 461.3 | 540.3 | 461.6 | 480.6 |
| 60: 0 | 471.1 | 555.6 | 469.6 | 490.5 |

SAMPLE D14/A60U
 UL TEST NO. 2



T E S T R E C O R D D14/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D14/A0 and as shown in ILL. 39.

The fire and hose stream tests were conducted on June 6, 1986 and identified by UL as Test No. 5.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 0.5 | Heavy black smoke issued from the assembly. |
| 1.5 | The heavy black smoke had decreased in intensity. |
| 6 | Light smoke issued from the periphery of the assembly. |
| 25 | The steel plate bowed upward and turned blackish in color. |
| 28 | Smoke intensity around the periphery of the assembly had increased. |
| 30 | The PVC pipe at the interface of the steel pipe was charring and melting along with the PVC union ring. |
| 40 | The PVC pipe was falling off the steel pipe. |
| 57 | The PVC pipe at the PVC union was heavily charred. |
| 60 | Test terminated. |

Note: After the test was terminated, the wire supporting the PVC pipe was removed and the PVC pipe collapsed.

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 40.

- > A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 41 through 41B.

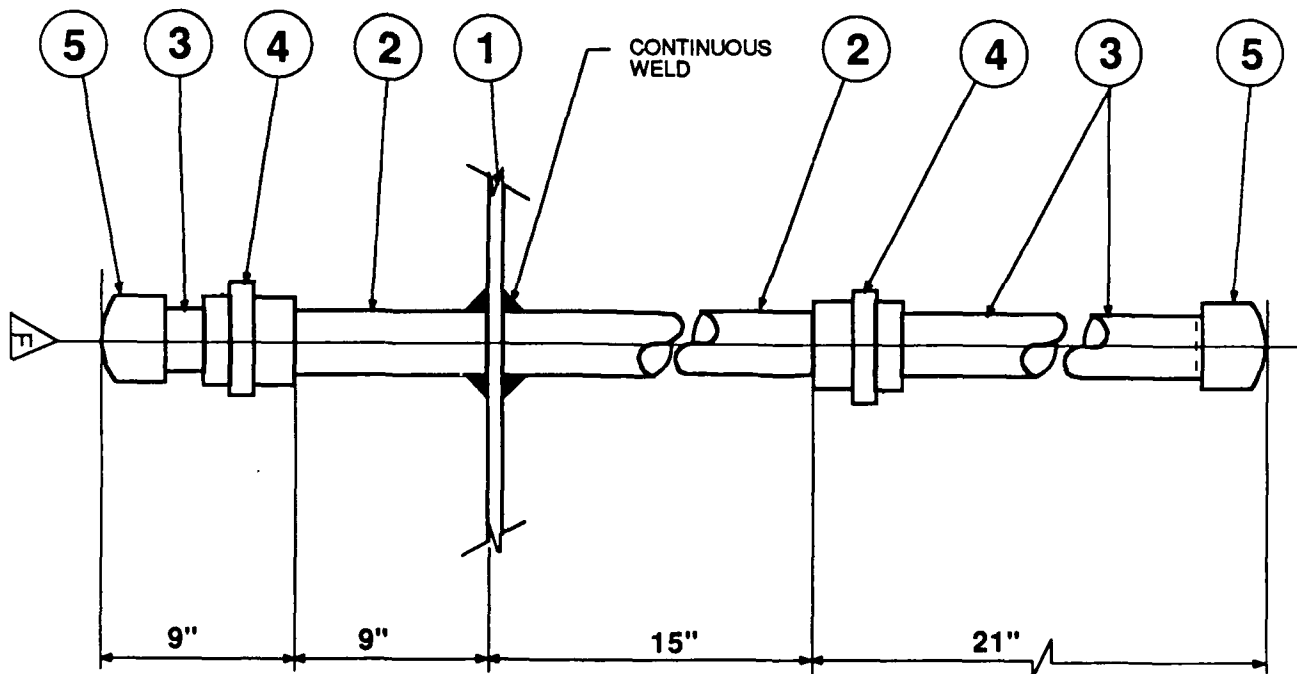
HOSE STREAM TEST:

Water passed through an opening that was present due to the PVC pipe on the exposed side being consumed during the fire endurance test, and the PVC pipe on the unexposed side collapsing after the fire endurance test.

Pictorial History - Photographs were taken before, during and after the fire test.

D14/A0
UL TEST NO. 5

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 3" NOMINAL
DIA. SCHEDULE 40.
- ③ PVC (PLASTIC) PIPE 3" NOMINAL DIA.
SCHEDULE 40, ASTM D-1784/1785.
- ④ PVC (PLASTIC) UNION, FEMALE THREAD/SOCKET,
3" NOMINAL PIPE DIAMETER.
- ⑤ PVC (PLASTIC) CAP, 3" NOMINAL PIPE DIAMETER.



TEST SAMPLE NO. D-14A
PVC (PLASTIC) PIPE
WITH STEEL SPIGOT

(R&DC GRAPHIC 12)

USNC 142
ILL. 39

SAMPLE D14/A0
TEST DATE JUNE 6, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, at interface of steel pipe and union. |
| 3 | On the surface of penetrant PVC union - (18 in. above steel plate). |
| 4 | On penetrant, at the interface of PVC union and PVC pipe. |
| 5 | On penetrant, 12 in. above steel plate. |
| 6 | On top of penetrant. |
| 7 | On penetrant, 24 in. above steel plate. |
| 8 | On steel plate, 3 in. from penetrant. |
| 9 | On steel plate, 6 in. from penetrant. |
| 10 | On steel plate, 6 in. from penetrant. |
| 11 | On steel plate, 12 in. from penetrant. |
| 12 | On steel plate, 12 in. from penetrant. |

USNC142
ILL. 40

U.S. COAST GUARD
 UL Test No. 5 - D14/A0
 86NK8673/USNC142
 6-6-86

| Temperature Degrees F | | | | |
|-----------------------|-------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 71.5 | 70.4 | 69.4 | 69.3 |
| 4: 0 | 112.7 | 77.1 | 73.9 | 70.2 |
| 8: 0 | 238.1 | 106.2 | 93.2 | 74.3 |
| 12: 0 | 396.3 | 151.5 | 123.0 | 83.1 |
| 16: 0 | 518.6 | 202.1 | 149.7 | 94.7 |
| 20: 0 | 597.8 | 247.9 | 172.8 | 107.2 |
| 24: 0 | 647.0 | 291.5 | 189.2 | 118.8 |
| 28: 0 | 682.7 | 327.3 | 205.8 | 129.9 |
| 32: 0 | 710.3 | 362.0 | 222.0 | 140.5 |
| 36: 0 | 728.1 | 382.0 | 238.1 | 150.1 |
| 40: 0 | 744.9 | 393.1 | 253.6 | 159.7 |
| 44: 0 | 755.2 | 401.1 | 263.9 | 169.7 |
| 48: 0 | 763.9 | 417.4 | 274.5 | 179.8 |
| 52: 0 | 773.9 | 437.4 | 283.1 | 189.7 |
| 56: 0 | 782.3 | 467.1 | 289.9 | 200.0 |
| 60: 0 | 789.7 | 483.6 | 294.3 | 208.1 |

FILE USNC142
 ILL. 41

U.S. COAST GUARD
 UL Test No. 5 - D14/A0
 86NK8673/USNC142
 6-6-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|--------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 69.5 | 69.6 | 70.4 | 73.2 |
| 4: 0 | 82.9 | 70.0 | 72.7 | 429.4 |
| 8: 0 | 120.4 | 75.5 | 85.7 | 945.4 |
| 12: 0 | 180.6 | 83.0 | 105.6 | 1051.6 |
| 16: 0 | 249.1 | 95.0 | 125.6 | 1108.6 |
| 20: 0 | 310.4 | 108.6 | 141.5 | 1162.0 |
| 24: 0 | 359.9 | 120.7 | 155.2 | 1205.3 |
| 28: 0 | 398.8 | 131.1 | 168.8 | 1247.7 |
| 32: 0 | 431.1 | 140.4 | 180.7 | 1287.7 |
| 36: 0 | 457.2 | 148.3 | 191.9 | 1313.5 |
| 40: 0 | 479.0 | 153.5 | 203.9 | 1337.2 |
| 44: 0 | 495.0 | 157.1 | 214.7 | 1351.8 |
| 48: 0 | 509.3 | 160.8 | 224.4 | 1369.6 |
| 52: 0 | 524.3 | 166.8 | 233.9 | 1389.4 |
| 56: 0 | 539.3 | 172.6 | 242.6 | 1396.1 |
| 60: 0 | 549.2 | 177.5 | 248.6 | 1402.0 |

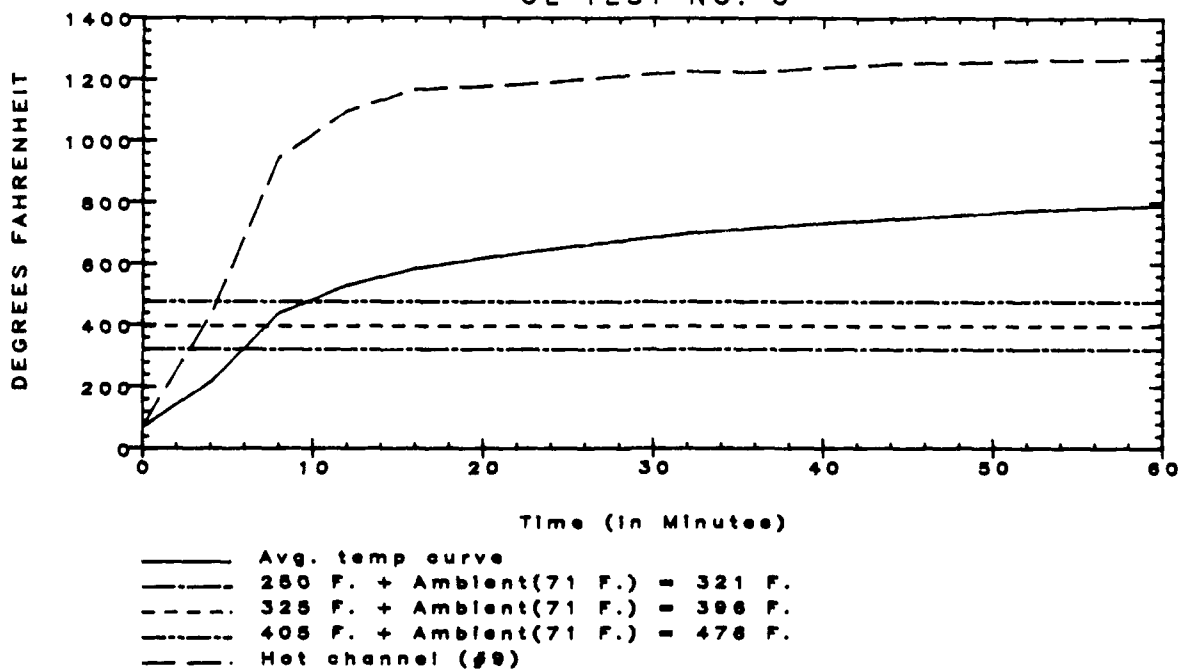
FILE USNC142
 ILL. 41A

U.S. COAST GUARD
 UL Test No. 5 - D14/A0
 86NK8673/USNC142
 6-6-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|--------|--------|--------|--------|
| TIME | | | | |
| 0: 0 | 72.2 | 73.5 | 72.8 | 73.5 |
| 4: 0 | 433.1 | 419.2 | 359.5 | 381.2 |
| 8: 0 | 943.8 | 934.6 | 827.2 | 825.3 |
| 12: 0 | 1096.9 | 1039.9 | 1049.4 | 996.7 |
| 16: 0 | 1166.2 | 1092.8 | 1137.7 | 1071.4 |
| 20: 0 | 1178.3 | 1139.1 | 1150.5 | 1116.1 |
| 24: 0 | 1191.0 | 1179.1 | 1160.1 | 1163.2 |
| 28: 0 | 1210.9 | 1212.4 | 1173.1 | 1203.7 |
| 32: 0 | 1227.4 | 1239.1 | 1184.9 | 1252.1 |
| 36: 0 | 1224.3 | 1266.7 | 1201.1 | 1291.6 |
| 40: 0 | 1238.5 | 1287.0 | 1222.1 | 1321.1 |
| 44: 0 | 1252.6 | 1310.0 | 1235.3 | 1344.3 |
| 48: 0 | 1255.4 | 1329.3 | 1244.4 | 1370.3 |
| 52: 0 | 1263.8 | 1356.4 | 1259.3 | 1399.7 |
| 56: 0 | 1264.1 | 1365.7 | 1261.8 | 1407.9 |
| 60: 0 | 1269.1 | 1381.9 | 1266.0 | 1416.2 |

SAMPLE D14/A0
 UL TEST NO. 5



T E S T R E C O R D D15/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D15/A60U and as shown in ILL. 42.

The fire and hose stream tests were conducted on June 17, 1986 and identified by UL as Test No. 21.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 15 | The steel deck along with the insulation was bowing downward. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 43.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 44 through 44B. The 36 min and 40 min temperature readings were not recorded during the fire test due to a malfunction of the Data Logger.

HOSE STREAM TEST:

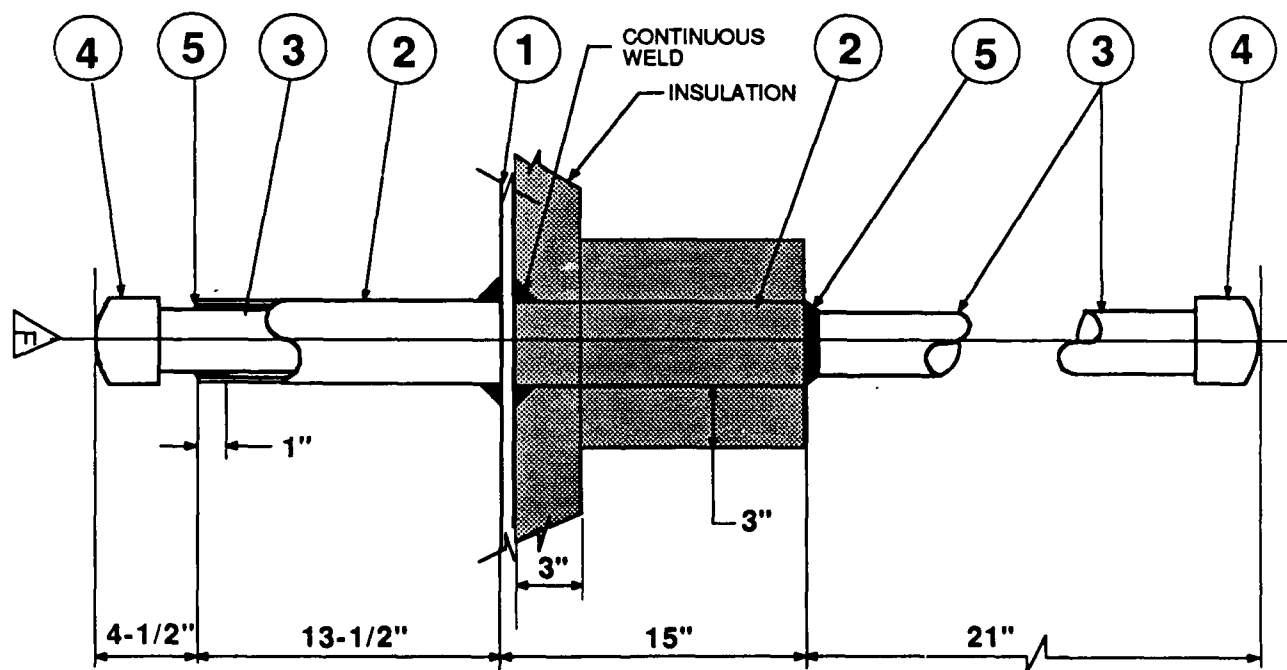
The PVC pipe partially collapsed during the hose stream test, yet no water passed through the assembly because of the sealant used at the interface of the PVC pipe and steel pipe.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D15/A60U
UL TEST NO. 21

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 4" NOMINAL
DIA. SCHEDULE 40.
- ③ PVC (PLASTIC) PIPE 3" NOMINAL DIA.
SCHEDULE 40, ASTM D-1784/1785.
- ④ PVC (PLASTIC) CAP, 3" NOMINAL PIPE DIAMETER.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-15A
PVC (PLASTIC) PIPE
WITH STEEL SPIGOT

(R&DC GRAPHIC 15)

USNC 142
ILL. 42

SAMPLE D15/A60U
TEST DATE JUNE 17, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On top of penetrant. |
| 2 | On penetrant, 4 in. above steel plate. |
| 3 | On penetrant, 6 in. above steel plate. |
| 4 | On penetrant, 12 in. above steel plate. |
| 5 | On penetrant, 16 in. above steel plate. |
| 6 | At interface of penetrant insulation and steel plate insulation. |
| 7 | On penetrant, 24 in. above steel plate. |
| 8 | On steel plate insulation, 12 in. from penetrant. |
| 9 | On steel plate insulation seam, 12 in. from penetrant. |
| 10 | On steel plate insulation, 6 in. from penetrant. |
| 11 | On steel plate insulation seam, 6 in. from penetrant. |
| 12 | At interface of steel pipe and PVC pipe, 15 in. above steel plate. |

USNC142
ILL. 43

U.S. COAST GUARD
 UL Test No. 21 - D5/A60U
 86NK8673/USNC142
 6-17-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 68.3 | 69.2 | 69.8 | 68.3 |
| 4: 0 | 69.7 | 69.8 | 68.9 | 67.3 |
| 8: 0 | 72.1 | 70.0 | 69.6 | 69.1 |
| 12: 0 | 71.8 | 77.0 | 70.3 | 71.6 |
| 16: 0 | 71.7 | 89.3 | 71.7 | 73.1 |
| 20: 0 | 72.8 | 91.8 | 73.7 | 74.0 |
| 24: 0 | 73.8 | 140.2 | 78.9 | 78.3 |
| 28: 0 | 74.8 | 233.7 | 89.2 | 83.2 |
| 32: 0 | 75.0 | 340.5 | 100.6 | 88.3 |
| 44: 0 | 81.3 | 468.2 | 134.7 | 102.4 |
| 48: 0 | 83.3 | 477.9 | 149.1 | 106.7 |
| 52: 0 | 84.0 | 483.9 | 161.3 | 110.8 |
| 56: 0 | 86.7 | 492.9 | 174.1 | 115.5 |
| 60: 0 | 88.4 | 502.0 | 187.7 | 119.4 |

FILE USNC142
 ILL. 44

U.S. COAST GUARD
 UL Test No. 21 - D15/A60U
 86NK8673/USNC142
 6-17-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 68.8 | 67.7 | 67.5 | 68.9 |
| 4: 0 | 71.9 | 69.4 | 70.7 | 70.3 |
| 8: 0 | 74.9 | 73.0 | 73.2 | 72.0 |
| 12: 0 | 77.4 | 82.9 | 73.0 | 78.8 |
| 16: 0 | 79.8 | 92.1 | 74.5 | 86.8 |
| 20: 0 | 84.9 | 108.0 | 77.7 | 91.4 |
| 24: 0 | 88.1 | 178.1 | 79.6 | 130.7 |
| 28: 0 | 91.0 | 302.0 | 82.3 | 219.8 |
| 32: 0 | 94.3 | 401.5 | 84.1 | 314.3 |
| 44: 0 | 108.0 | 508.3 | 91.8 | 410.0 |
| 48: 0 | 113.8 | 520.9 | 93.6 | 425.8 |
| 52: 0 | 119.1 | 531.7 | 96.4 | 438.8 |
| 56: 0 | 125.1 | 546.3 | 99.0 | 453.3 |
| 60: 0 | 129.5 | 556.8 | 101.1 | 467.9 |

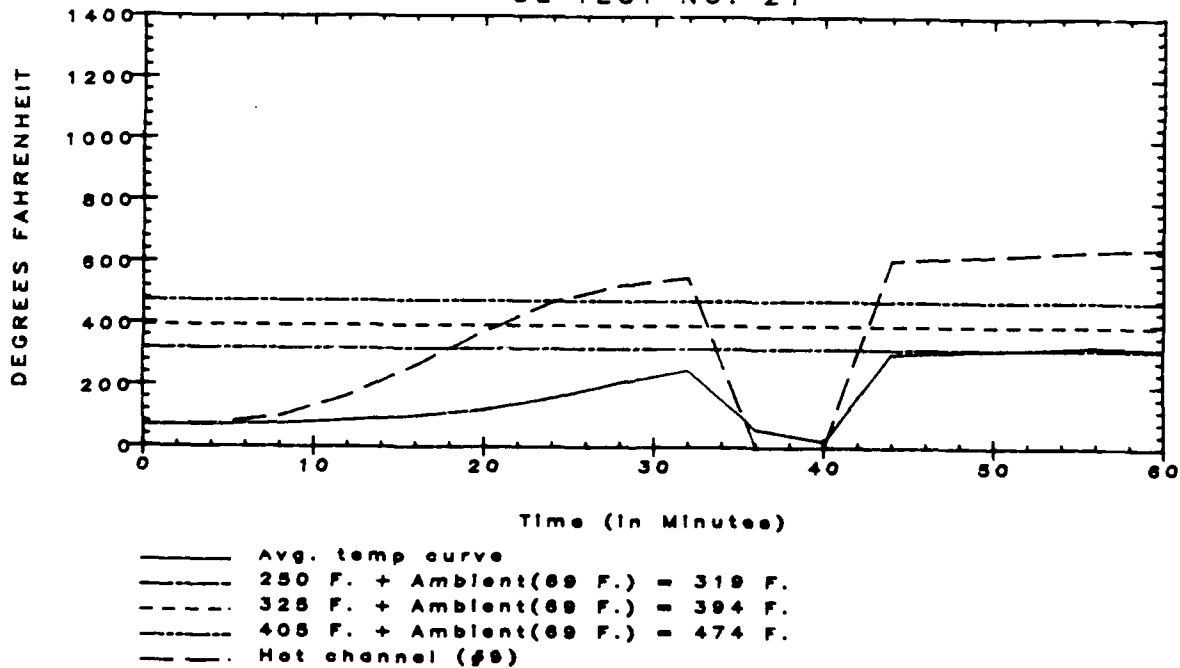
FILE USNC142
 ILL. 44A

U.S. COAST GUARD
 UL Test No. 21 - D15/A60U
 86NK8673/USNC142
 6-17-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 69.1 | 68.5 | 68.8 | 69.9 |
| 4: 0 | 73.9 | 70.4 | 70.0 | 71.0 |
| 8: 0 | 98.5 | 74.7 | 80.7 | 74.2 |
| 12: 0 | 164.1 | 85.7 | 99.5 | 76.0 |
| 16: 0 | 262.9 | 91.7 | 126.3 | 81.6 |
| 20: 0 | 373.2 | 133.3 | 176.3 | 87.4 |
| 24: 0 | 471.6 | 233.4 | 262.0 | 94.0 |
| 28: 0 | 525.4 | 343.6 | 367.8 | 102.5 |
| 32: 0 | 551.6 | 402.5 | 436.8 | 111.4 |
| 44: 0 | 608.5 | 457.4 | 523.0 | 153.7 |
| 48: 0 | 619.7 | 466.1 | 538.8 | 163.2 |
| 52: 0 | 630.1 | 472.5 | 551.0 | 173.8 |
| 56: 0 | 641.8 | 483.6 | 563.8 | 185.7 |
| 60: 0 | 652.0 | 494.8 | 576.5 | 0.0 |

SAMPLE D15/A60U
 UL TEST NO. 21



T E S T R E C O R D D16/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D16/A60U and as shown in ILL. 45.

The fire and hose stream tests were conducted on June 9, 1986 and identified by UL as Test No. 8.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 2 | The exposed side of the PVC pipe was heavily charred. |
| 10 | The PVC pipe on the exposed side was consumed. |
| 26 | UL's technical staff tied the PVC pipe for support because the PVC pipe had started to lean. |
| 38 | An opening developed at the interface of the steel plate insulation and the penetrant insulation due to downward bowing of the steel plate. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 46.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 47 through 47B.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

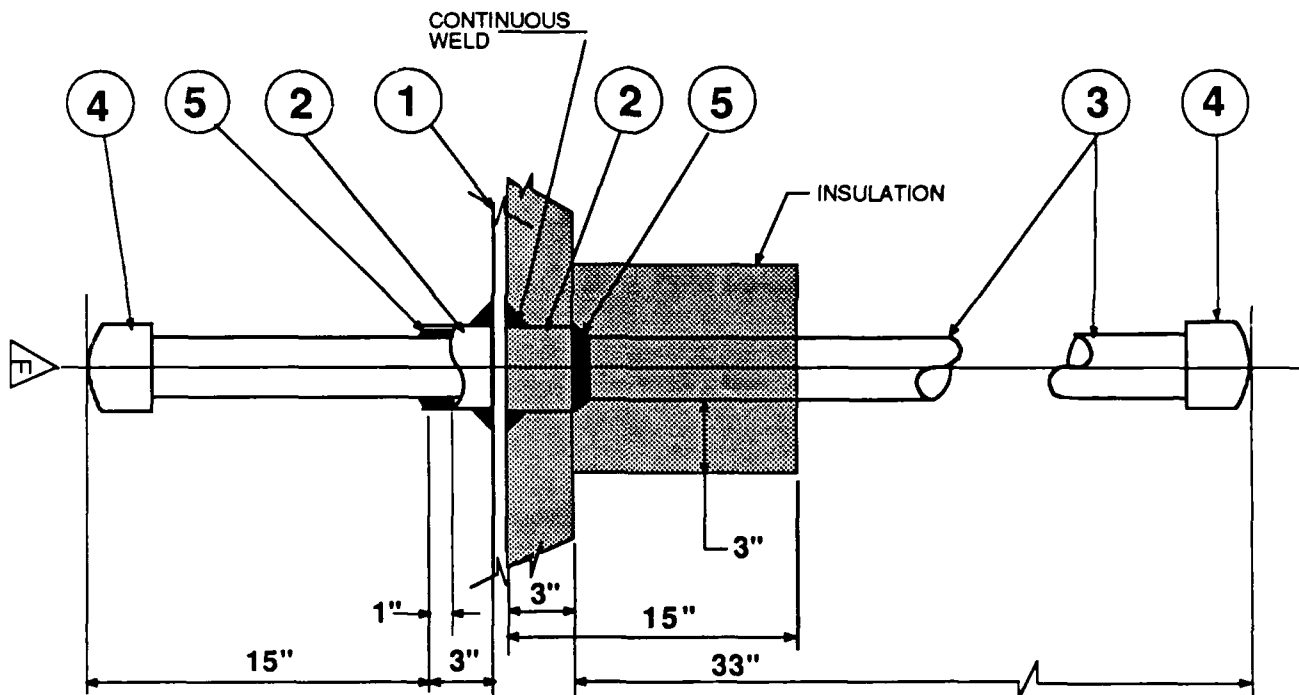
HOSE STREAM TEST:

Water passed through an opening that was present due to the PVC pipe on the exposed side being consumed during the fire endurance test, and the PVC pipe along with its insulation on the unexposed side collapsing during the initial impact of the hose stream.

Pictorial History - Photographs were taken before, during and after the fire test.

D16/A60U
UL TEST NO. 8

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 4" NOMINAL
DIA. SCHEDULE 40.
- ③ PVC (PLASTIC) PIPE 3" NOMINAL DIA.
SCHEDULE 40, ASTM D-1784/1785.
- ④ PVC (PLASTIC) CAP, 3" NOMINAL PIPE DIAMETER.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-16A
PVC (PLASTIC) PIPE
WITH STEEL SPIGOT
(R&DC GRAPHIC 18)

USNC 142
ILL. 45

SAMPLE D16/A60U
TEST DATE JUNE 9, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On interface of penetrant insulation and steel plate insulation. |
| 2 | On top of penetrant. |
| 3 | On penetrant, 4 in. above steel plate. |
| 4 | On penetrant, 6 in. above steel plate. |
| 5 | On penetrant, 12 in. above steel plate. |
| 6 | On PVC pipe, 18 in. above steel plate. |
| 7 | On PVC pipe, 24 in. above steel plate. |
| 8 | On steel plate insulation, 12 in. from penetrant. |
| 9 | On steel plate insulation seam, 12 in. from penetrant. |
| 10 | On steel plate insulation, 4 in. from penetrant. |
| 11 | On steel plate insulation seam, 4 in. from penetrant. |

USNC142
ILL. 46

U.S. COAST GUARD
 UL Test No. 8 - D16/A60U
 86NK8673/USNC142
 6-9-86

| | Temperature Degrees F | | | |
|------------|-----------------------|------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 76.6 | 75.5 | 74.1 | 73.9 |
| 4: 0 | 78.3 | 76.0 | 75.3 | 74.4 |
| 8: 0 | 82.2 | 79.4 | 78.0 | 75.9 |
| 12: 0 | 93.1 | 79.2 | 81.5 | 76.8 |
| 16: 0 | 103.2 | 78.0 | 89.9 | 80.6 |
| 20: 0 | 145.3 | 78.0 | 96.8 | 82.6 |
| 24: 0 | 244.8 | 78.1 | 113.5 | 87.8 |
| 28: 0 | 382.4 | 78.3 | 155.1 | 95.7 |
| 32: 0 | 526.3 | 80.1 | 239.3 | 106.9 |
| 36: 0 | 567.4 | 81.1 | 302.9 | 119.9 |
| 40: 0 | 581.2 | 81.7 | 338.1 | 135.1 |
| 44: 0 | 595.9 | 82.8 | 362.2 | 152.8 |
| 48: 0 | 617.2 | 84.3 | 384.3 | 168.0 |
| 52: 0 | 644.6 | 85.3 | 403.6 | 180.5 |
| 56: 0 | 676.6 | 86.8 | 427.8 | 192.8 |
| 60: 0 | 710.4 | 86.6 | 456.1 | 205.2 |

FILE USNC142
 ILL. 47

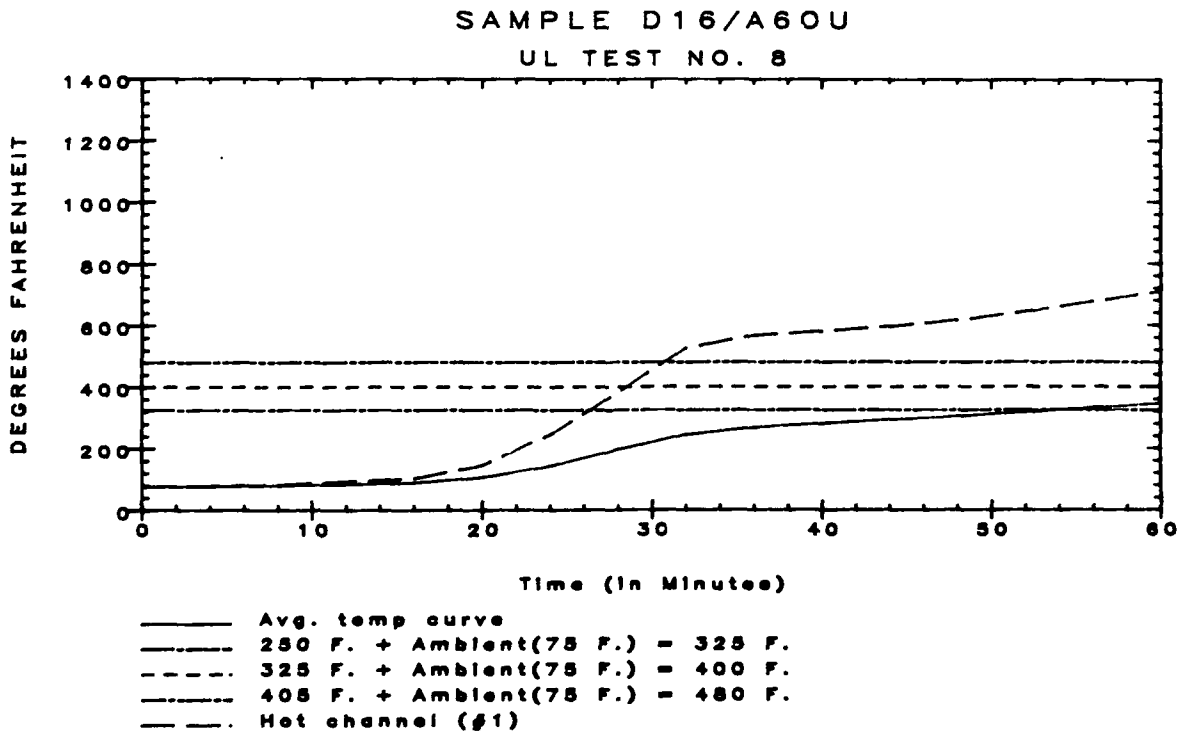
U.S. COAST GUARD
 UL Test No. 8 - D16/A60U
 86NK8673/USNC142
 6-9-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 74.9 | 73.6 | 75.2 | 75.3 |
| 4: 0 | 74.2 | 78.0 | 78.2 | 76.7 |
| 8: 0 | 75.2 | 81.6 | 80.0 | 79.6 |
| 12: 0 | 76.3 | 83.6 | 81.5 | 84.0 |
| 16: 0 | 77.6 | 87.3 | 82.6 | 92.1 |
| 20: 0 | 79.1 | 90.9 | 83.0 | 115.7 |
| 24: 0 | 84.5 | 92.7 | 84.9 | 177.6 |
| 28: 0 | 86.4 | 94.4 | 87.4 | 283.0 |
| 32: 0 | 92.3 | 95.5 | 89.7 | 358.4 |
| 36: 0 | 97.8 | 96.6 | 93.1 | 396.4 |
| 40: 0 | 102.3 | 97.6 | 93.4 | 417.3 |
| 44: 0 | 111.2 | 98.9 | 93.5 | 433.9 |
| 48: 0 | 111.0 | 99.8 | 94.6 | 447.3 |
| 52: 0 | 114.5 | 100.6 | 95.5 | 459.4 |
| 56: 0 | 118.5 | 102.5 | 98.0 | 471.5 |
| 60: 0 | 123.9 | 104.0 | 99.8 | 482.7 |

FILE USNC142
 ILL. 47A

U.S. COAST GUARD
 UL Test No. 8 - D16/A60U
 86NK8673/USNC142
 6-9-86

| | Temperature Degrees F | | |
|------------|-----------------------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 |
| TIME | | | |
| 0: 0 | 76.8 | 77.3 | 77.2 |
| 4: 0 | 78.1 | 78.4 | 78.6 |
| 8: 0 | 80.0 | 80.5 | 82.0 |
| 12: 0 | 87.4 | 88.8 | 92.3 |
| 16: 0 | 93.4 | 100.5 | 100.5 |
| 20: 0 | 116.9 | 151.6 | 144.5 |
| 24: 0 | 171.4 | 258.8 | 233.5 |
| 28: 0 | 254.6 | 396.7 | 345.2 |
| 32: 0 | 333.6 | 477.8 | 436.4 |
| 36: 0 | 384.6 | 508.9 | 474.6 |
| 40: 0 | 414.5 | 525.2 | 494.9 |
| 44: 0 | 435.1 | 543.5 | 515.2 |
| 48: 0 | 449.2 | 566.3 | 541.4 |
| 52: 0 | 467.4 | 594.7 | 575.7 |
| 56: 0 | 469.6 | 623.3 | 615.1 |
| 60: 0 | 481.0 | 648.2 | 654.4 |



T E S T R E C O R D D17/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D17/A60E and as shown in ILL. 48.

The fire and hose stream tests were conducted on June 6, 1986 and identified by UL as Test No. 6.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|--|
| 42 | No significant changes had occurred. |
| 43 | Steam issued from the top of the penetrant. |
| 60 | No other significant changes occurred during the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 49.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 50 through 50B.

Pressure Record - The pressure within the small-scale test furnace throughout the fire test was +0.01 in./H₂O (+2.5 Pa).

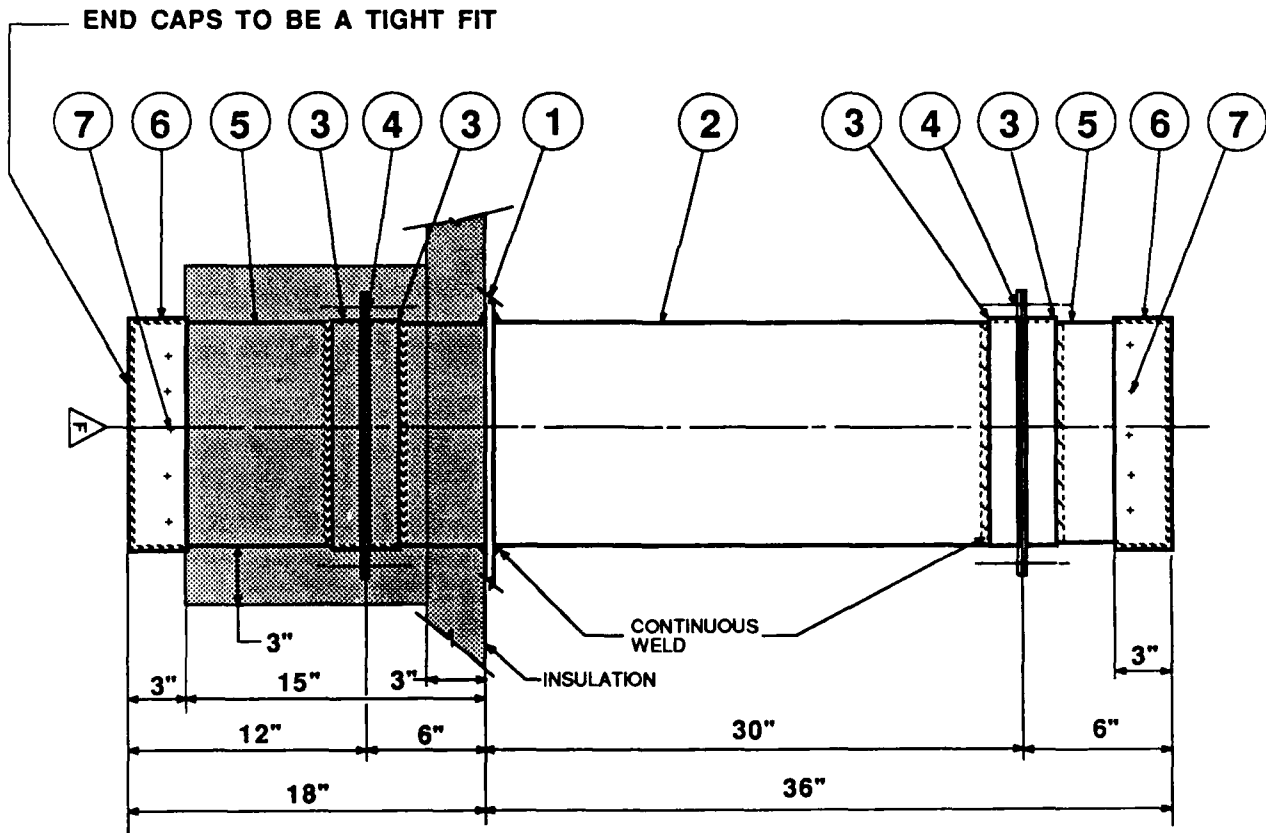
HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

- ① STEEL PLATE 36"X36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE 12" NOMINAL DIA.,
SCHEDULE 20, WALL THICKNESS, 0.250"
- ③ 1-1/2"X1-1/2"X1/8" ANGLE BAR STEEL,
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ④ 3/8" DIA STEEL BOLTS, NUTS, AND WASHERS
(8 REQUIRED AT EACH JOINT)
- ⑤ 12" NOMINAL DIA STEEL CIRCULAR VENT DUCT
(SPIRO METAL 24G, OR EQUIVALENT) SPIRAL-WOUND TYPE
- ⑥ STEEL EXTERIOR CAP, 24G
- ⑦ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP)



TEST SAMPLE D-17A
VENT DUCT WITH
STEEL SPIGOT (CIRC)
(R&DC GRAPHIC 18)

USNC 142
ILL. 48

SAMPLE D17/A60E
TEST DATE JUNE 6, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at overlap of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate over insulation, 3 in. from penetrant. |
| 8 | On steel plate over insulation, 4 in. from penetrant. |
| 9 | On steel plate over insulation seam, 4 in. from penetrant. |
| 10 | On steel plate over insulation, 8 in. from penetrant. |
| 11 | On steel plate over insulation seam, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 49

U.S. COAST GUARD
 UL Test No. 6 - D17/A60E
 86NK8673/USNC142
 6-6-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 71.1 | 71.2 | 71.3 | 71.1 |
| 4: 0 | 79.9 | 78.9 | 76.0 | 77.2 |
| 8: 0 | 100.3 | 96.8 | 89.5 | 90.0 |
| 12: 0 | 133.3 | 125.2 | 109.8 | 104.9 |
| 16: 0 | 168.6 | 156.8 | 132.9 | 119.6 |
| 20: 0 | 204.3 | 189.5 | 157.8 | 133.8 |
| 24: 0 | 239.4 | 221.8 | 182.4 | 148.0 |
| 28: 0 | 272.2 | 252.4 | 206.6 | 162.4 |
| 32: 0 | 304.3 | 282.3 | 230.6 | 175.9 |
| 36: 0 | 335.8 | 312.1 | 255.3 | 190.0 |
| 40: 0 | 366.3 | 340.5 | 280.4 | 205.8 |
| 44: 0 | 393.8 | 366.3 | 301.7 | 218.3 |
| 48: 0 | 420.5 | 391.4 | 323.9 | 231.7 |
| 52: 0 | 447.1 | 415.4 | 344.1 | 242.4 |
| 56: 0 | 471.3 | 437.9 | 360.5 | 251.0 |
| 60: 0 | 492.7 | 457.3 | 375.8 | 259.4 |

FILE USNC142
 ILL. 50

U.S. COAST GUARD
 UL Test No. 6 - D17/A60E
 86NK8673/USNC142
 6-6-86

Temperature Degrees F

| CHAN(NOS.) | 5 | 6 | 7 | 8 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 70.2 | 70.2 | 70.4 | 71.9 |
| 4: 0 | 74.8 | 74.1 | 72.0 | 73.2 |
| 8: 0 | 85.5 | 83.3 | 78.3 | 76.9 |
| 12: 0 | 101.9 | 96.9 | 92.9 | 85.0 |
| 16: 0 | 120.6 | 112.4 | 110.1 | 98.4 |
| 20: 0 | 140.5 | 133.4 | 131.5 | 115.6 |
| 24: 0 | 161.0 | 145.9 | 155.9 | 136.2 |
| 28: 0 | 180.9 | 163.1 | 183.5 | 159.3 |
| 32: 0 | 201.2 | 180.4 | 212.2 | 184.5 |
| 36: 0 | 221.8 | 198.3 | 230.3 | 220.6 |
| 40: 0 | 243.3 | 217.1 | 257.0 | 246.5 |
| 44: 0 | 261.4 | 232.9 | 294.3 | 261.6 |
| 48: 0 | 281.6 | 250.0 | 320.1 | 281.8 |
| 52: 0 | 299.6 | 265.3 | 331.4 | 313.5 |
| 56: 0 | 312.6 | 276.3 | 348.5 | 337.0 |
| 60: 0 | 325.3 | 287.1 | 367.7 | 355.5 |

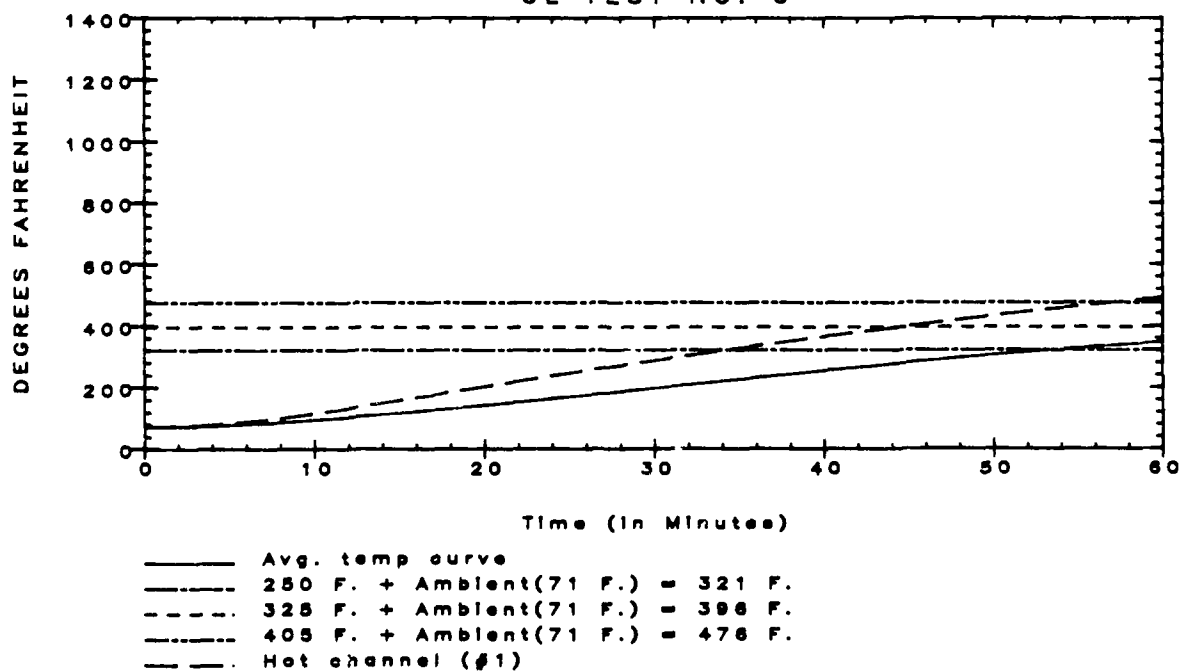
FILE USNC142
 ILL. 50A

U.S. COAST GUARD
 UL Test No. 6 - D17/A60E
 86NK8673/USNC142
 6-6-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 71.5 | 71.7 | 71.3 | 71.5 |
| 4: 0 | 71.6 | 72.5 | 71.0 | 96.6 |
| 8: 0 | 77.2 | 74.6 | 74.5 | 130.5 |
| 12: 0 | 87.4 | 78.9 | 80.3 | 160.0 |
| 16: 0 | 100.8 | 85.6 | 87.8 | 186.0 |
| 20: 0 | 118.4 | 95.2 | 98.2 | 208.3 |
| 24: 0 | 139.0 | 110.5 | 114.2 | 228.6 |
| 28: 0 | 160.6 | 128.2 | 133.3 | 247.6 |
| 32: 0 | 184.7 | 146.0 | 152.3 | 267.6 |
| 36: 0 | 210.4 | 162.9 | 170.0 | 287.5 |
| 40: 0 | 235.4 | 181.6 | 186.8 | 305.6 |
| 44: 0 | 259.6 | 200.2 | 207.4 | 316.0 |
| 48: 0 | 283.2 | 218.9 | 227.2 | 334.2 |
| 52: 0 | 304.8 | 236.5 | 245.3 | 345.1 |
| 56: 0 | 324.4 | 252.9 | 268.2 | 360.3 |
| 60: 0 | 341.9 | 267.4 | 275.8 | 369.9 |

SAMPLE D17/A60E
 UL TEST NO. 6



T E S T R E C O R D D17/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D17/A60U and as shown in ILL. 51.

The fire and hose stream tests were conducted on June 14, 1986 and identified by UL as Test No. 17.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 22 | Steel spigot became blackish in color. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 52.

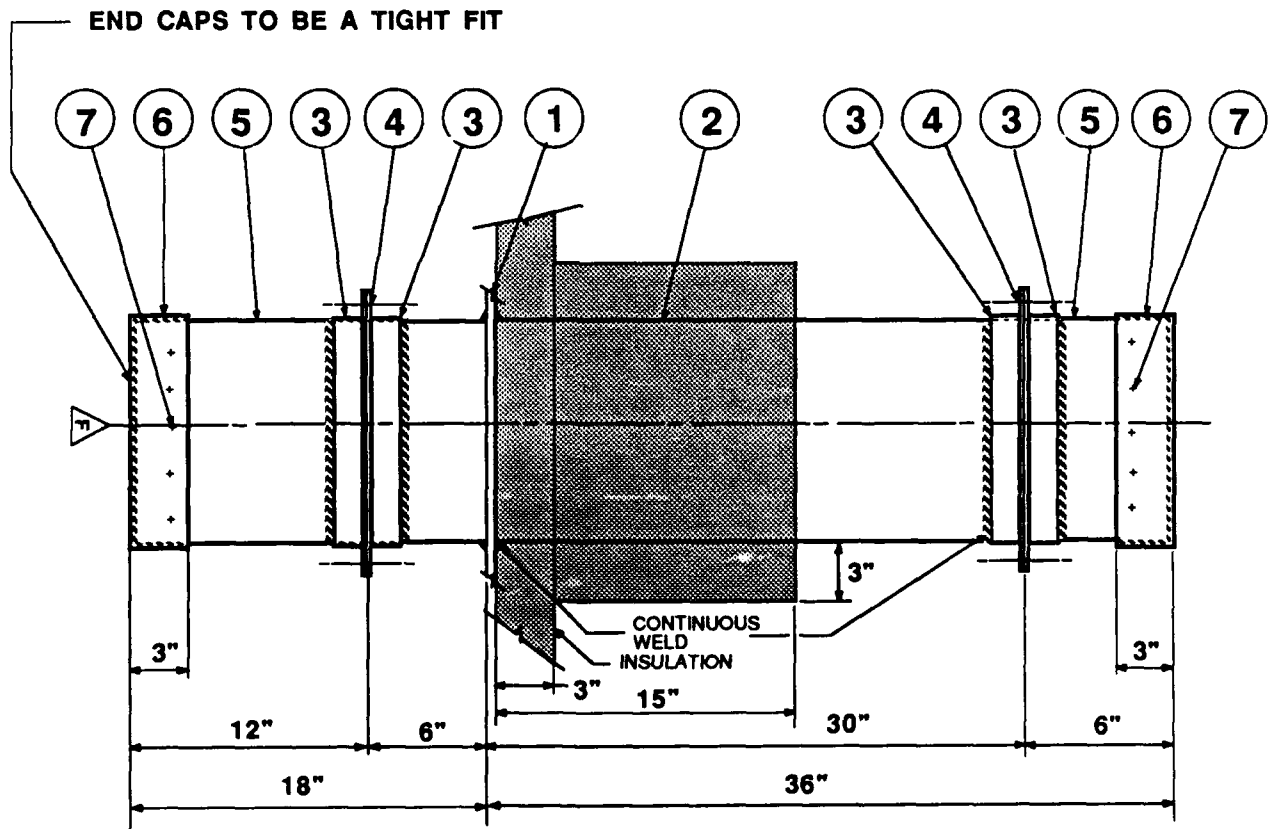
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 53 through 53B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36"X36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE 12" NOMINAL DIA.,
SCHEDULE 20, WALL THICKNESS, 0.250"
- ③ 1-1/2"X1-1/2"X1/8" ANGLE BAR STEEL,
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ④ 3/8" DIA STEEL BOLTS, NUTS, AND WASHERS
(8 REQUIRED AT EACH JOINT)
- ⑤ 12" NOMINAL DIA STEEL CIRCULAR VENT DUCT
(SPIRO METAL 24G, OR EQUIVALENT) SPIRAL-WOUND TYPE
- ⑥ STEEL EXTERIOR CAP, 24G
- ⑦ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP)



TEST SAMPLE D-17A
VENT DUCT WITH
STEEL SPIGOT (CIRC)
(R&DC GRAPHIC 19)

USNC 142
ILL. 51

SAMPLE D17/A60U
TEST DATE JUNE 14, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at overlap of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On interface of steel plate insulation and penetrant insulation. |
| 8 | On steel plate insulation, 4 in. from penetrant. |
| 9 | On steel plate insulation seam, 4 in. from penetrant. |
| 10 | On steel plate insulation, 8 in. from penetrant. |
| 11 | On steel plate insulation seam, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 52

U.S. COAST GUARD
 UL Test No. 17 - D17/A60U
 86NK8673/USNC142
 6-14-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 70.0 | 70.7 | 69.7 | 69.5 |
| 4: 0 | 71.4 | 70.9 | 71.2 | 86.7 |
| 8: 0 | 72.6 | 71.6 | 71.4 | 130.7 |
| 12: 0 | 74.2 | 72.3 | 72.0 | 170.7 |
| 16: 0 | 77.2 | 73.6 | 72.9 | 204.2 |
| 20: 0 | 82.1 | 75.0 | 74.4 | 234.2 |
| 24: 0 | 87.6 | 80.1 | 76.6 | 260.6 |
| 28: 0 | 94.0 | 86.3 | 79.9 | 287.3 |
| 32: 0 | 114.9 | 98.1 | 86.7 | 317.8 |
| 36: 0 | 150.7 | 117.5 | 94.0 | 339.9 |
| 40: 0 | 198.1 | 142.5 | 103.9 | 360.7 |
| 44: 0 | 261.1 | 175.6 | 115.3 | 372.7 |
| 48: 0 | 332.5 | 222.8 | 130.2 | 389.5 |
| 52: 0 | 388.1 | 283.0 | 148.4 | 404.7 |
| 56: 0 | 423.8 | 340.1 | 173.3 | 417.1 |
| 60: 0 | 445.7 | 381.4 | 194.4 | 428.9 |

FILE USNC142
 ILL. 53

U.S. COAST GUARD
 UL Test No. 17 - D17/A60U
 86NK8673/USNC142
 6-14-86

Temperature Degrees F

| CHAN(NOS.) | 5 | 6 | 7 | 8 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 70.5 | 70.1 | 70.5 | 71.8 |
| 4: 0 | 80.0 | 79.4 | 71.4 | 73.8 |
| 8: 0 | 115.0 | 108.4 | 73.0 | 80.1 |
| 12: 0 | 162.2 | 146.6 | 77.2 | 92.3 |
| 16: 0 | 215.9 | 187.4 | 86.6 | 105.0 |
| 20: 0 | 274.2 | 229.5 | 95.0 | 125.6 |
| 24: 0 | 329.9 | 270.8 | 101.0 | 173.3 |
| 28: 0 | 382.1 | 308.6 | 138.2 | 251.8 |
| 32: 0 | 432.2 | 342.7 | 218.1 | 351.7 |
| 36: 0 | 479.5 | 377.4 | 343.0 | 431.8 |
| 40: 0 | 524.4 | 407.0 | 453.6 | 467.0 |
| 44: 0 | 564.3 | 434.2 | 524.3 | 481.6 |
| 48: 0 | 596.3 | 458.4 | 579.4 | 498.6 |
| 52: 0 | 624.4 | 478.0 | 615.9 | 516.5 |
| 56: 0 | 647.4 | 495.7 | 637.6 | 534.3 |
| 60: 0 | 668.0 | 511.5 | 655.1 | 549.9 |

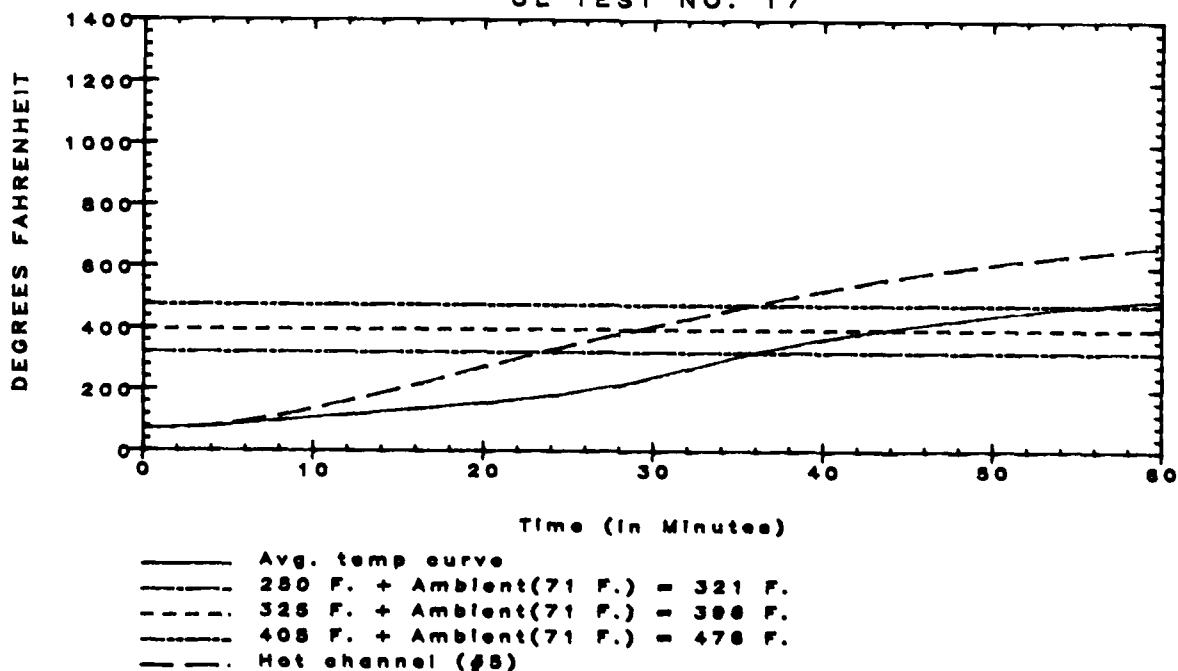
FILE USNC142
 ILL. 53A

U.S. COAST GUARD
 UL Test No. 17 - D17/A60U
 86NK8673/USNC142
 6-14-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 71.8 | 71.4 | 70.9 | 70.4 |
| 4: 0 | 74.4 | 72.1 | 71.7 | 131.5 |
| 8: 0 | 80.6 | 73.8 | 73.8 | 240.9 |
| 12: 0 | 91.1 | 78.5 | 82.0 | 295.3 |
| 16: 0 | 103.7 | 88.5 | 92.6 | 345.2 |
| 20: 0 | 121.3 | 93.4 | 94.3 | 381.6 |
| 24: 0 | 158.5 | 105.4 | 118.7 | 400.0 |
| 28: 0 | 225.8 | 148.4 | 175.0 | 421.6 |
| 32: 0 | 324.3 | 222.4 | 261.3 | 442.1 |
| 36: 0 | 418.0 | 306.6 | 343.4 | 472.2 |
| 40: 0 | 490.3 | 367.7 | 396.6 | 486.1 |
| 44: 0 | 545.2 | 402.4 | 427.2 | 496.4 |
| 48: 0 | 572.2 | 423.5 | 447.7 | 504.3 |
| 52: 0 | 587.9 | 439.8 | 462.1 | 519.2 |
| 56: 0 | 602.1 | 455.2 | 468.5 | 528.9 |
| 60: 0 | 617.0 | 470.3 | 472.6 | 543.5 |

SAMPLE D17/A60U
 UL TEST NO. 17



T E S T R E C O R D D17/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D17/A0 and as shown in ILL. 54.

The fire and hose stream tests were conducted on June 9, 1986 and identified by UL as Test No. 7.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 5 | The steel plate became blackish in color. |
| 19 | The steel spigot became blackish in color. |
| 20 | The gasket material at the top of the duct assembly liquefied. |
| 25 | The gasket material was bubbling and dripping downward. The steel plate was bowing downward. |
| 35 | A flash of flame occurred around the periphery. This was due to ignition of loose fibers from the furnace insulation. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 55.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 56 through 56B. Thermocouple No. 8 malfunctioned at the 60 min temperature reading.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

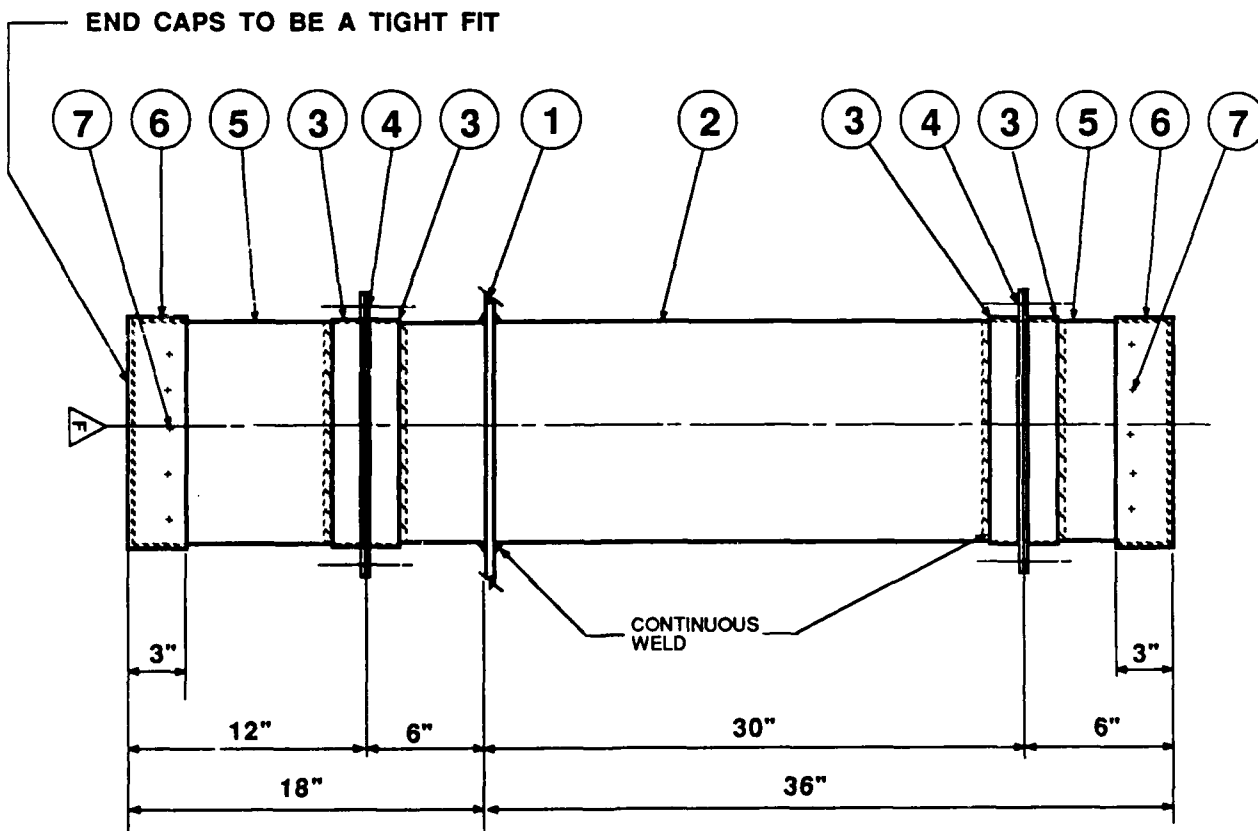
HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D17/A0
UL TEST NO. 7

- ① STEEL PLATE 36"X36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE 12" NOMINAL DIA.,
SCHEDULE 20, WALL THICKNESS, 0.250"
- ③ 1-1/2"X1-1/2"X1/8" ANGLE BAR STEEL,
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ④ 3/8" DIA STEEL BOLTS, NUTS, AND WASHERS
(8 REQUIRED AT EACH JOINT)
- ⑤ 12" NOMINAL DIA STEEL CIRCULAR VENT DUCT
(SPIRO METAL 24G, OR EQUIVALENT) SPIRAL-WOUND TYPE
- ⑥ STEEL EXTERIOR CAP, 24G
- ⑦ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP)



TEST SAMPLE D-17A
VENT DUCT WITH
STEEL SPIGOT (CIRC)
(R&DC GRAPHIC 17)

USNC 142
ILL. 54

SAMPLE D17/A0
TEST DATE JUNE 9, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at overlap of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate, 3 in. from penetrant. |
| 8 | On steel plate, 4 in. from penetrant. |
| 9 | On steel plate, 4 in. from penetrant. |
| 10 | On steel plate, 8 in. from penetrant. |
| 11 | On steel plate, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 55

U.S. COAST GUARD
 UL Test No. 7 - D17/A0
 86NK8673/USNC142
 6-9-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 73.1 | 73.5 | 73.2 | 71.6 |
| 4: 0 | 116.8 | 101.1 | 88.5 | 89.6 |
| 8: 0 | 242.6 | 199.6 | 142.5 | 131.3 |
| 12: 0 | 405.8 | 338.8 | 225.9 | 169.3 |
| 16: 0 | 556.2 | 475.9 | 318.0 | 205.5 |
| 20: 0 | 672.8 | 586.9 | 402.9 | 233.4 |
| 24: 0 | 761.4 | 671.2 | 473.3 | 259.8 |
| 28: 0 | 821.7 | 739.8 | 532.2 | 283.6 |
| 32: 0 | 863.1 | 784.1 | 575.8 | 307.4 |
| 36: 0 | 894.4 | 817.0 | 609.7 | 325.3 |
| 40: 0 | 916.0 | 838.4 | 633.9 | 343.0 |
| 44: 0 | 937.6 | 860.3 | 657.1 | 357.1 |
| 48: 0 | 955.5 | 878.0 | 674.5 | 369.7 |
| 52: 0 | 973.8 | 895.8 | 691.6 | 377.5 |
| 56: 0 | 990.2 | 910.5 | 702.9 | 387.2 |
| 60: 0 | 1001.0 | 920.2 | 714.3 | 397.9 |

FILE USNC142
 ILL. 56

U.S. COAST GUARD
UL Test No. 7 - D17/A0
86NK8673/USNC142
6-9-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|--------|--------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 72.1 | 72.1 | 72.9 | 72.9 |
| 4: 0 | 84.8 | 82.7 | 396.6 | 792.0 |
| 8: 0 | 123.8 | 115.4 | 777.5 | 1033.9 |
| 12: 0 | 180.2 | 157.7 | 157.7 | 1149.4 |
| 16: 0 | 242.8 | 204.8 | 1154.9 | 1230.9 |
| 20: 0 | 303.5 | 250.5 | 1242.4 | 1288.6 |
| 24: 0 | 356.6 | 293.9 | 1294.0 | 1325.7 |
| 28: 0 | 404.9 | 331.9 | 1327.8 | 1360.2 |
| 32: 0 | 444.9 | 366.6 | 1362.9 | 1396.0 |
| 36: 0 | 475.1 | 392.8 | 1396.7 | 1421.4 |
| 40: 0 | 499.7 | 414.8 | 1422.2 | 1444.9 |
| 44: 0 | 521.0 | 433.4 | 1447.0 | 1464.0 |
| 48: 0 | 536.6 | 448.2 | 1466.9 | 1486.5 |
| 52: 0 | 551.6 | 461.8 | 1491.6 | 1503.6 |
| 56: 0 | 563.2 | 472.6 | 1509.2 | 1518.3 |
| 60: 0 | 574.9 | 483.0 | 1523.0 | 0.0 |

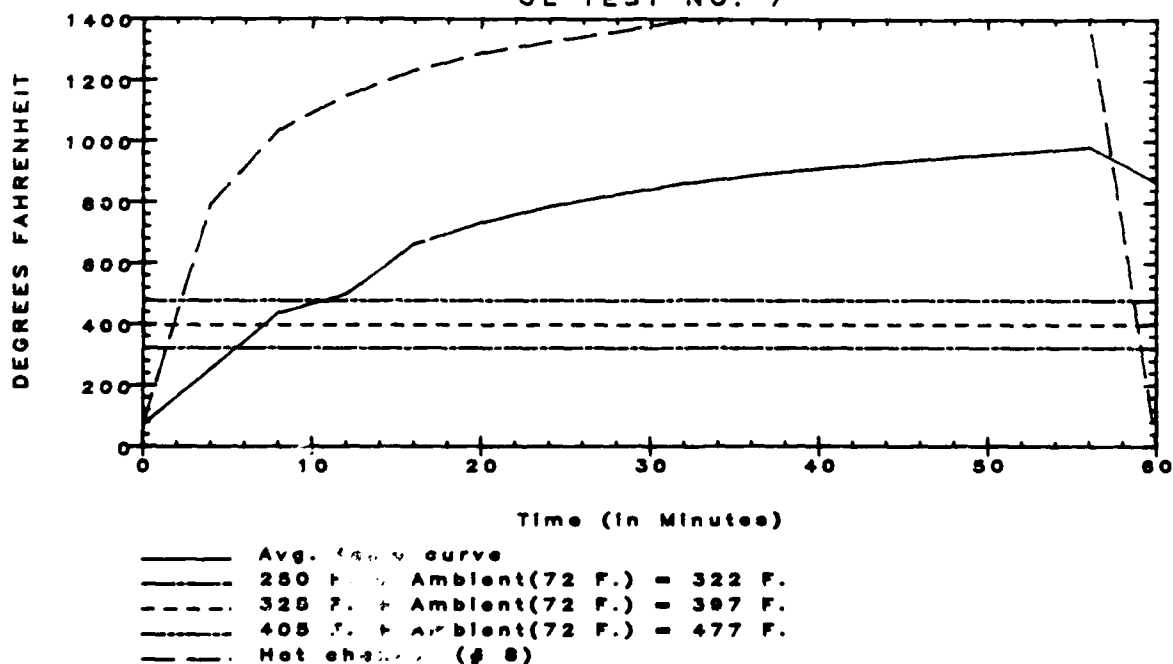
FILE USNC142
ILL. 56A

U.S. COAST GUARD
 UL Test No. 7 - D17/A0
 86NK8673/USNC142
 6-9-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|--------|--------|--------|-------|
| TIME | | | | |
| 0: 0 | 72.0 | 72.9 | 72.0 | 71.8 |
| 4: 0 | 406.7 | 403.6 | 361.7 | 131.9 |
| 8: 0 | 799.4 | 762.5 | 687.2 | 227.7 |
| 12: 0 | 1030.5 | 980.5 | 907.5 | 285.7 |
| 16: 0 | 1125.7 | 1090.3 | 1022.7 | 325.1 |
| 20: 0 | 1194.7 | 1171.0 | 1092.3 | 358.5 |
| 24: 0 | 1242.8 | 1221.3 | 1139.5 | 385.2 |
| 28: 0 | 1278.8 | 1261.3 | 1172.1 | 405.3 |
| 32: 0 | 1304.5 | 1294.5 | 1197.9 | 424.3 |
| 36: 0 | 1330.8 | 1321.1 | 1225.5 | 443.9 |
| 40: 0 | 1358.7 | 1337.1 | 1251.0 | 457.8 |
| 44: 0 | 1384.1 | 1359.5 | 1275.3 | 473.5 |
| 48: 0 | 1402.3 | 1379.5 | 1292.5 | 486.8 |
| 52: 0 | 1426.8 | 1397.0 | 1314.3 | 487.6 |
| 56: 0 | 1447.2 | 1420.1 | 1338.3 | 497.2 |
| 60: 0 | 1462.8 | 1443.2 | 1354.9 | 500.5 |

SAMPLE D17/A0
 UL TEST NO. 7



T E S T R E C O R D D19/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D19/A60U and as shown in ILL. 57.

The fire and hose stream tests were conducted on June 18, 1986 and identified by UL as Test No. 24.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|----------------------|
|-----------------------|----------------------|

| | |
|----|--|
| 60 | No significant changes occurred during the remainder of the fire test. |
|----|--|

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILLS. 58 through 58A.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 59 through 59C. Thermocouple No. 8 was inoperable until 52 min into the fire endurance test.

Pressure Record - The pressure within the small-scale test furnace ranged from +0.005 in./H₂O to +0.01 in./H₂O, (+1.24 Pa to +2.5 Pa), throughout the duration of the fire endurance test.

HOSE STREAM TEST:

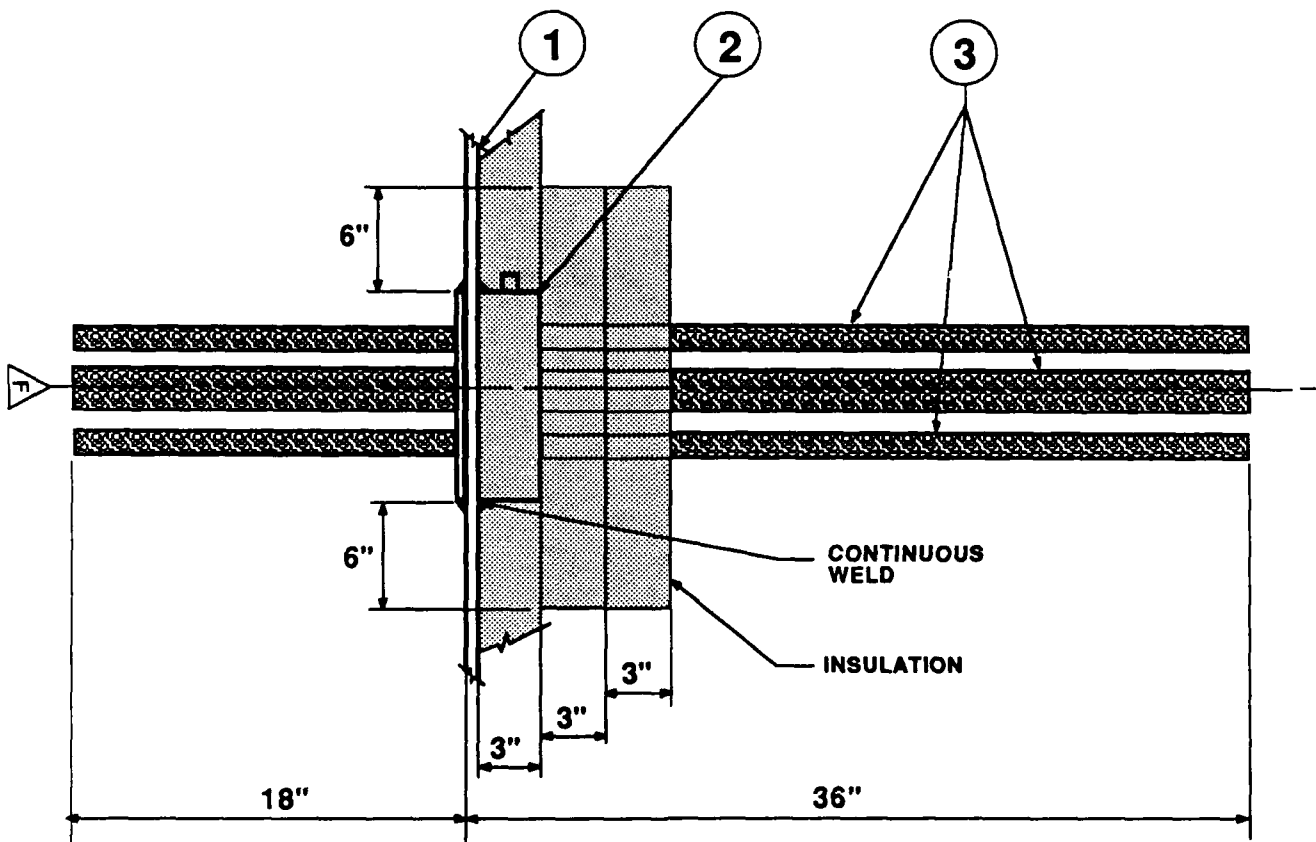
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D19/A60U
UL TEST NO. 24

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT) .
- ② STEEL MULTI-CABLE TRANSIT
- ③ VARIOUS SIZES OF ELECTRICAL (MARINE) CABLES,
CCG APPROVED (MINIMUM OF SIX (6) CABLES).



TEST SAMPLE D-19A ELECTRICAL
CABLES IN MULTI-CABLE TRANSIT

(R&DC GRAPHIC 31)

USNC 142
ILL. 57

SAMPLE D19/A60U
TEST DATE JUNE 18, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On interface of steel plate insulation and transit insulation. |
| 2 | On interface of steel plate insulation and transit insulation. |
| 3 | On top of transit insulation, 3 in. from edge of transit insulation. |
| 4 | On top of transit insulation, 3 in. from edge of transit insulation. |
| 5 | On steel plate insulation seam, 3 in. from transit insulation. |
| 6 | On steel plate insulation seam, 3 in. from transit insulation. |
| 7 | On Type 1 cable, 9 in. from steel plate. |
| 8 | On Type 1 cable, 12 in. from steel plate. |
| 9 | On Type 1 cable, 18 in. from steel plate. |
| 10 | On Type 1 cable, 24 in. from steel plate. |
| 11 | On Type 2 cable, 9 in. from steel plate. |
| 12 | On Type 2 cable, 12 in. from steel plate. |
| 13 | On Type 2 cable, 18 in. from steel plate. |
| 14 | On Type 2 cable, 24 in. from steel plate. |
| 15 | On Type 3 cable, 9 in. from steel plate. |

USNC142
ILL. 58

| <u>T.C.</u> | <u>Location</u> |
|---|---|
| 16 | On Type 3 cable, 12 in. from steel plate. |
| 17 | On Type 3 cable, 18 in. from steel plate. |
| 18 | On Type 3 cable, 24 in. from steel plate. |
| Type 1 cable = 8 SHLD PAIR/6 AWG CANADA MARINEX X1 300 VLT. | |
| Type 2 cable = 14 AWG/10 WIRE CANADA MARINEX X1 750 VLT. | |
| Type 3 cable = Thermo Electric Type PLTC THCPL EXTN Type JX 20 AWG | |

Note: Cable types will vary on the remaining D19 samples due to the different cables used to construct the sample. UL chose a large diameter cable, a medium diameter cable and a small diameter cable for each D19 sample. Cable types were matched whenever possible.

USNC142
ILL. 58A

U.S. COAST GUARD
 UL Test No. 24 - D19/A60U
 86NK8673/USNC142
 6-18-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 82.1 | 83.7 | 89.3 | 83.0 |
| 4: 0 | 84.4 | 84.6 | 88.6 | 83.9 |
| 8: 0 | 86.4 | 85.9 | 88.2 | 84.2 |
| 12: 0 | 90.0 | 89.6 | 87.0 | 84.6 |
| 16: 0 | 99.5 | 93.9 | 88.2 | 85.1 |
| 20: 0 | 143.6 | 107.9 | 88.8 | 86.1 |
| 24: 0 | 247.6 | 142.1 | 90.3 | 86.7 |
| 28: 0 | 399.4 | 208.5 | 91.7 | 88.2 |
| 32: 0 | 525.5 | 312.5 | 93.3 | 90.6 |
| 36: 0 | 578.5 | 426.5 | 95.5 | 93.0 |
| 40: 0 | 598.4 | 512.6 | 98.2 | 95.4 |
| 44: 0 | 610.7 | 554.3 | 99.9 | 96.0 |
| 48: 0 | 602.7 | 592.5 | 101.4 | 97.3 |
| 52: 0 | 612.5 | 620.0 | 102.7 | 103.4 |
| 56: 0 | 602.6 | 642.0 | 103.8 | 113.6 |
| 60: 0 | 589.8 | 655.4 | 107.0 | 121.3 |

FILE USNC142
 ILL. 59

U.S. COAST GUARD
 UL Test No. 24 - D19/A60U
 86NK8673/USNC142
 6-18-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 84.2 | 83.0 | 81.1 | 81.4 |
| 4: 0 | 89.3 | 84.7 | 81.8 | 81.4 |
| 8: 0 | 103.9 | 97.0 | 83.8 | 30.8 |
| 12: 0 | 126.1 | 150.0 | 89.1 | 79.5 |
| 16: 0 | 160.7 | 252.7 | 97.5 | 76.6 |
| 20: 0 | 217.5 | 364.8 | 111.6 | 72.1 |
| 24: 0 | 273.2 | 549.5 | 129.7 | 65.3 |
| 28: 0 | 360.6 | 711.8 | 151.4 | 57.3 |
| 32: 0 | 431.0 | 789.8 | 175.8 | 46.7 |
| 36: 0 | 494.0 | 857.2 | 192.4 | 36.7 |
| 40: 0 | 552.5 | 948.2 | 212.2 | 25.8 |
| 44: 0 | 585.7 | 975.0 | 233.8 | 15.5 |
| 48: 0 | 594.5 | 976.9 | 254.6 | 5.2 |
| 52: 0 | 595.9 | 976.4 | 270.9 | 171.0 |
| 56: 0 | 597.2 | 976.8 | 289.1 | 179.2 |
| 60: 0 | 599.7 | 979.5 | 308.6 | 188.4 |

FILE USNC142
 ILL. 59A

U.S. COAST GUARD
 UL Test No. 24 - D19/A60U
 86NK8673/USNC142
 6-18-86

| | Temperature Degrees F | | | | |
|------------|-----------------------|-------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 | 13 |
| TIME | | | | | |
| 0: 0 | 81.0 | 82.2 | 81.4 | 81.8 | 82.1 |
| 4: 0 | 82.3 | 82.4 | 81.0 | 82.5 | 82.7 |
| 8: 0 | 82.6 | 82.7 | 83.7 | 83.4 | 83.3 |
| 12: 0 | 83.3 | 83.3 | 87.0 | 85.8 | 84.2 |
| 16: 0 | 84.3 | 84.2 | 93.7 | 88.7 | 85.2 |
| 20: 0 | 86.1 | 85.3 | 102.9 | 93.3 | 86.8 |
| 24: 0 | 88.8 | 86.0 | 114.6 | 99.9 | 89.2 |
| 28: 0 | 91.6 | 88.9 | 130.2 | 107.9 | 91.4 |
| 32: 0 | 94.6 | 91.2 | 152.9 | 117.9 | 93.8 |
| 36: 0 | 98.5 | 94.6 | 170.0 | 126.4 | 96.5 |
| 40: 0 | 102.8 | 94.9 | 187.6 | 136.4 | 99.3 |
| 44: 0 | 107.8 | 97.9 | 202.8 | 146.6 | 103.2 |
| 48: 0 | 112.9 | 101.2 | 219.5 | 153.5 | 106.7 |
| 52: 0 | 117.7 | 104.2 | 234.7 | 166.3 | 110.8 |
| 56: 0 | 122.0 | 107.4 | 248.7 | 174.0 | 113.8 |
| 60: 0 | 126.7 | 109.8 | 262.1 | 176.7 | 117.0 |

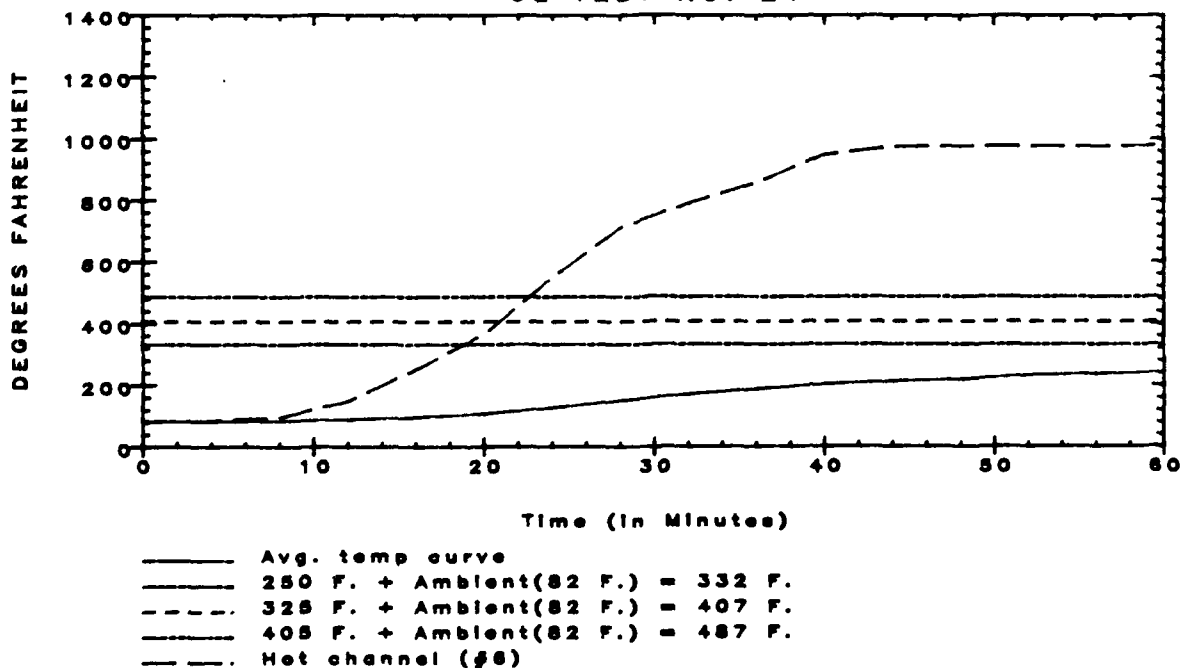
FILE USNC142
 ILL. 59B

U.S. COAST GUARD
 UL Test No. 24 - D19/A60U
 86NK8673/USNC142
 6-18-86

Temperature Degrees F

| CHAN(NOS.) | 14 | 15 | 16 | 17 | 18 |
|------------|-------|-------|-------|-------|-------|
| TIME | | | | | |
| 0: 0 | 82.3 | 81.4 | 82.1 | 82.3 | 82.2 |
| 4: 0 | 81.7 | 82.5 | 82.0 | 83.1 | 82.9 |
| 8: 0 | 83.4 | 82.2 | 83.6 | 83.8 | 83.6 |
| 12: 0 | 84.3 | 84.0 | 84.6 | 85.2 | 84.9 |
| 16: 0 | 85.2 | 87.2 | 85.7 | 86.4 | 86.1 |
| 20: 0 | 86.6 | 92.6 | 86.3 | 88.1 | 88.1 |
| 24: 0 | 87.4 | 101.7 | 90.1 | 90.1 | 90.9 |
| 28: 0 | 90.6 | 112.5 | 92.6 | 92.0 | 92.5 |
| 32: 0 | 92.7 | 126.0 | 95.9 | 95.5 | 93.8 |
| 36: 0 | 95.1 | 141.3 | 99.2 | 97.3 | 94.8 |
| 40: 0 | 98.2 | 159.2 | 102.8 | 99.6 | 96.2 |
| 44: 0 | 101.4 | 174.4 | 107.5 | 103.1 | 98.8 |
| 48: 0 | 104.6 | 185.9 | 111.5 | 105.8 | 101.2 |
| 52: 0 | 108.1 | 202.0 | 116.9 | 108.7 | 103.6 |
| 56: 0 | 110.8 | 202.8 | 119.4 | 109.7 | 104.5 |
| 60: 0 | 113.5 | 211.9 | 121.6 | 111.0 | 105.8 |

SAMPLE D19/A60U
 UL TEST NO. 24



T E S T R E C O R D D19/A60-6ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D19/A60-6E and as shown in ILL. 60.

The fire and hose stream tests were conducted on June 26, 1986 and identified by UL as Test No. 35.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 0.25 | The cables ignited on the exposed side. |
| 5 | The steel plate became black in color around the periphery and was buckling and twisting. |
| 6 | Light smoke issued from the periphery. |
| 15 | Insulation was placed on the periphery of the assembly due to severe buckling of the steel plate. This severe buckling caused an opening into the test furnace. |
| 34 | The steel plate was glowing red at the periphery. The cables at the interface of the transit were issuing smoke. Additional insulation was placed at the periphery as it was at 15 min. |
| 38 | The smoke intensity from the cables increased. The cable jackets appeared to be getting soft at the interface of the transit. |
| 40 | The cable jackets were melting at the interface of the transit. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILLS. 61 through 61A.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 62 through 62D.

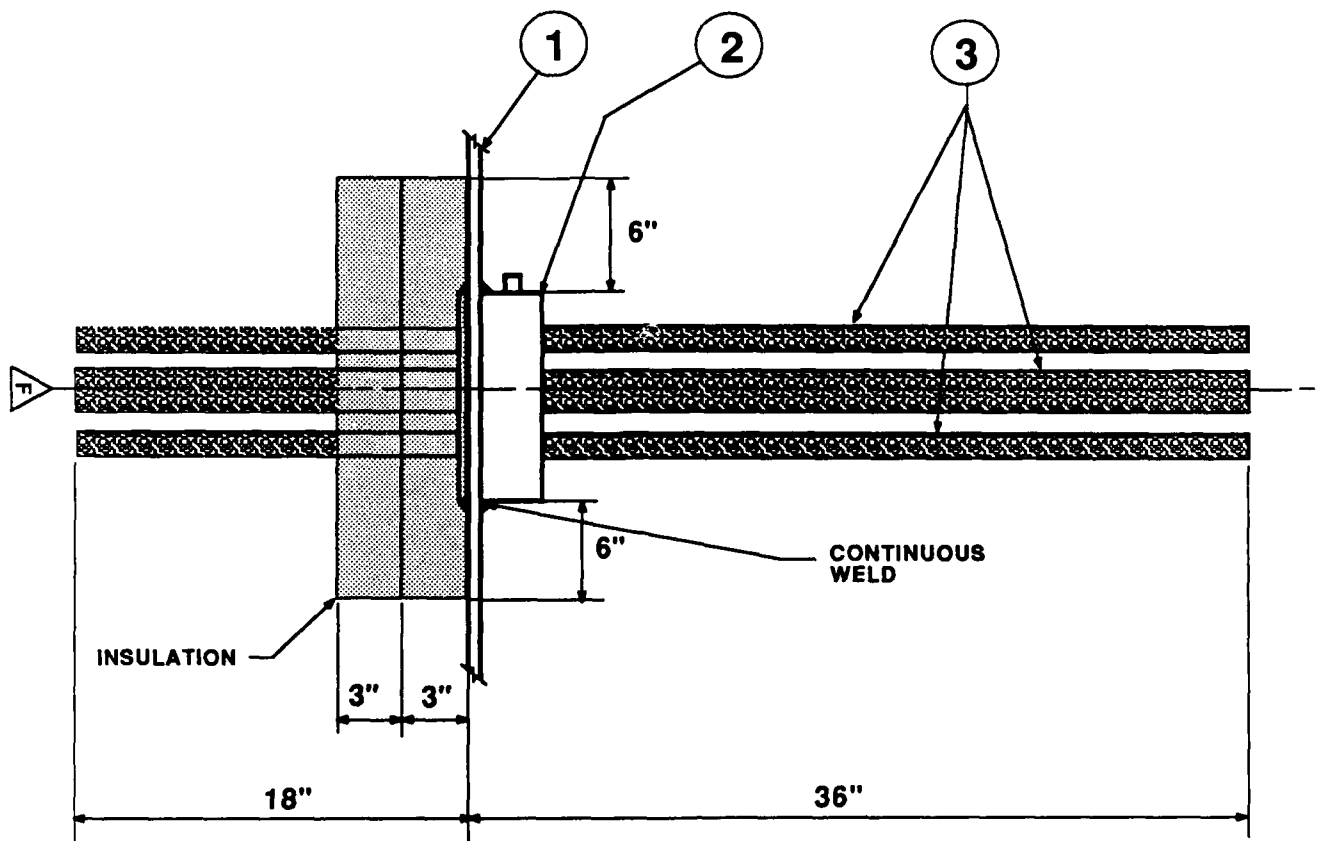
HOSE STREAM TEST:

A very small amount of water passed through the assembly at the interface of the transit grommets and the cables.

Pictorial History - Photographs were taken before, during and after the fire test.

D19/A60-6E
UL TEST NO. 35

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② STEEL MULTI-CABLE TRANSIT.
- ③ VARIOUS SIZES OF ELECTRICAL (MARINE) CABLES,
CCG APPROVED (MINIMUM OF SIX (6) CABLES).



TEST SAMPLE D-19A ELECTRICAL
CABLES IN MULTI-CABLE TRANSIT
(R&DC GRAPHIC 32)

USNC 142
ILL. 60

SAMPLE D19/A60-6E
TEST DATE JUNE 26, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On Type 1 cable, 6 in. above steel plate. |
| 2 | On Type 1 cable, 12 in. above steel plate. |
| 3 | On Type 1 cable, 18 in. above steel plate. |
| 4 | On Type 1 cable, 24 in. above steel plate. |
| 5 | On Type 2 cable, 6 in. above steel plate. |
| 6 | On Type 2 cable, 12 in. above steel plate. |
| 7 | On Type 2 cable, 18 in. above steel plate. |
| 8 | On Type 2 cable, 24 in. above steel plate. |
| 9 | On Type 3 cable, 6 in. above steel plate. |
| 10 | On Type 3 cable, 12 in. above steel plate. |
| 11 | On Type 3 cable, 18 in. above steel plate. |
| 12 | On Type 3 cable, 24 in. above steel plate. |
| 13 | On unexposed surface of grommet. |
| 14 | On top of grommet fastening screw. |
| 15 | On transit compression screw. |
| 16 | On unexposed surface of grommet joint. |
| 17 | On multi-cable transit frame, 1 in. above steel plate. |
| 18 | At interface of multi-cable transit frame and steel plate. |
| 19 | On steel plate, 3 in. from multi-cable transit. |

USNC142
ILL. 61

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 20 | On steel plate, 3 in. from multi-cable transit. |
| 21 | On steel plate, 6 in. from multi-cable transit. |
| 22 | On steel plate, 6 in. from multi-cable transit. |

Type 1 cable = 8 shld Pair/16 AWG Canada Wire Marinex X1 300 VT.
Type 2 cable = 14 AWG/16 Canada Wire Marinex X1 750VT.
Type 3 cable = E67179 16 AWG 300 VT. Power limited circuit
cable Class 2 or 3 Type PLTC.

USNC142
ILL. 61A

U.S. COAST GUARD
 UL Test No. 35 - D19/A60-6E
 86NK8673/USNC142
 6-26-86

| Temperature Degrees F | | | | |
|-----------------------|-------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 78.4 | 78.6 | 78.4 | 78.5 |
| 4: 0 | 81.1 | 83.7 | 82.4 | 81.4 |
| 8: 0 | 90.8 | 95.3 | 92.2 | 87.0 |
| 12: 0 | 111.4 | 120.1 | 109.2 | 100.1 |
| 16: 0 | 141.0 | 150.4 | 131.5 | 116.5 |
| 20: 0 | 171.2 | 179.5 | 150.8 | 131.9 |
| 24: 0 | 200.2 | 202.5 | 170.1 | 145.8 |
| 28: 0 | 226.7 | 224.1 | 186.8 | 158.2 |
| 32: 0 | 252.8 | 245.7 | 203.8 | 171.2 |
| 36: 0 | 276.8 | 264.8 | 219.4 | 183.2 |
| 40: 0 | 299.8 | 284.1 | 232.4 | 194.7 |
| 44: 0 | 320.8 | 298.8 | 243.9 | 205.0 |
| 48: 0 | 341.9 | 312.9 | 255.3 | 214.2 |
| 52: 0 | 360.6 | 329.4 | 267.2 | 223.5 |
| 56: 0 | 378.0 | 343.0 | 277.6 | 231.4 |
| 60: 0 | 395.9 | 355.0 | 286.1 | 238.6 |

FILE USNC142
 ILL. 62

U.S. COAST GUARD
 UL Test No. 35 - D19/A60-6E
 86NK8673/USNC142
 6-26-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 78.6 | 78.6 | 78.4 | 78.6 |
| 4: 0 | 83.8 | 83.7 | 85.2 | 79.2 |
| 8: 0 | 97.3 | 97.8 | 93.2 | 79.9 |
| 12: 0 | 128.2 | 125.4 | 112.9 | 80.7 |
| 16: 0 | 166.1 | 156.8 | 136.0 | 81.5 |
| 20: 0 | 198.5 | 180.0 | 155.6 | 82.0 |
| 24: 0 | 229.1 | 206.7 | 174.6 | 83.9 |
| 28: 0 | 259.1 | 230.5 | 192.1 | 84.9 |
| 32: 0 | 289.7 | 251.3 | 209.2 | 85.7 |
| 36: 0 | 314.9 | 272.0 | 224.2 | 86.6 |
| 40: 0 | 338.3 | 291.1 | 237.5 | 196.7 |
| 44: 0 | 357.8 | 307.1 | 249.4 | 205.6 |
| 48: 0 | 375.3 | 322.2 | 260.5 | 213.0 |
| 52: 0 | 393.3 | 336.7 | 273.2 | 221.3 |
| 56: 0 | 412.8 | 348.7 | 283.0 | 229.1 |
| 60: 0 | 428.7 | 359.2 | 291.5 | 236.5 |

FILE USNC142
 ILL. 62A

U.S. COAST GUARD
 UL Test No. 35 - D19/A60-6E
 86NK8673/USNC142
 6-26-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 78.8 | 78.8 | 78.6 | 78.6 |
| 4: 0 | 89.1 | 87.5 | 83.9 | 81.4 |
| 8: 0 | 117.6 | 106.5 | 95.3 | 88.5 |
| 12: 0 | 170.0 | 145.8 | 120.9 | 102.0 |
| 16: 0 | 224.5 | 187.4 | 150.0 | 119.5 |
| 20: 0 | 264.3 | 218.4 | 171.8 | 133.0 |
| 24: 0 | 298.6 | 249.5 | 197.5 | 149.8 |
| 28: 0 | 327.9 | 275.6 | 219.1 | 165.3 |
| 32: 0 | 353.8 | 296.6 | 235.9 | 178.8 |
| 36: 0 | 376.8 | 315.0 | 250.3 | 190.0 |
| 40: 0 | 405.2 | 332.7 | 263.2 | 199.9 |
| 44: 0 | 427.7 | 348.6 | 274.4 | 208.1 |
| 48: 0 | 451.7 | 363.2 | 285.5 | 214.9 |
| 52: 0 | 476.0 | 375.3 | 297.4 | 222.7 |
| 56: 0 | 494.9 | 387.9 | 305.9 | 228.3 |
| 60: 0 | 509.1 | 396.2 | 312.6 | 233.5 |

FILE USNC142
 ILL. 62B

U.S. COAST GUARD
 UL Test No. 35 - D19/A60-6E
 86NK8673/USNC142
 6-26-86

Temperature Degrees F

| CHAN(NOS.) | 13 | 14 | 15 | 16 | 17 |
|------------|-------|-------|-------|-------|-------|
| TIME | | | | | |
| 0: 0 | 78.5 | 78.1 | 78.4 | 78.6 | 78.6 |
| 4: 0 | 79.7 | 78.7 | 80.7 | 78.4 | 80.5 |
| 8: 0 | 87.2 | 81.5 | 92.5 | 85.8 | 93.9 |
| 12: 0 | 103.3 | 90.2 | 115.1 | 101.3 | 121.5 |
| 16: 0 | 129.3 | 104.6 | 147.1 | 127.3 | 159.7 |
| 20: 0 | 160.4 | 125.7 | 182.2 | 160.0 | 200.0 |
| 24: 0 | 193.0 | 149.2 | 211.5 | 195.6 | 234.9 |
| 28: 0 | 221.2 | 173.5 | 238.2 | 229.8 | 267.3 |
| 32: 0 | 248.8 | 197.3 | 263.3 | 262.4 | 297.0 |
| 36: 0 | 274.8 | 219.8 | 285.8 | 291.7 | 322.6 |
| 40: 0 | 301.4 | 241.3 | 307.4 | 319.8 | 346.1 |
| 44: 0 | 324.8 | 261.2 | 325.8 | 347.2 | 368.2 |
| 48: 0 | 345.1 | 280.7 | 342.1 | 364.1 | 388.8 |
| 52: 0 | 364.3 | 299.5 | 361.0 | 383.8 | 409.1 |
| 56: 0 | 376.6 | 317.7 | 376.4 | 391.1 | 429.7 |
| 60: 0 | 388.7 | 334.9 | 390.0 | 387.5 | 447.6 |

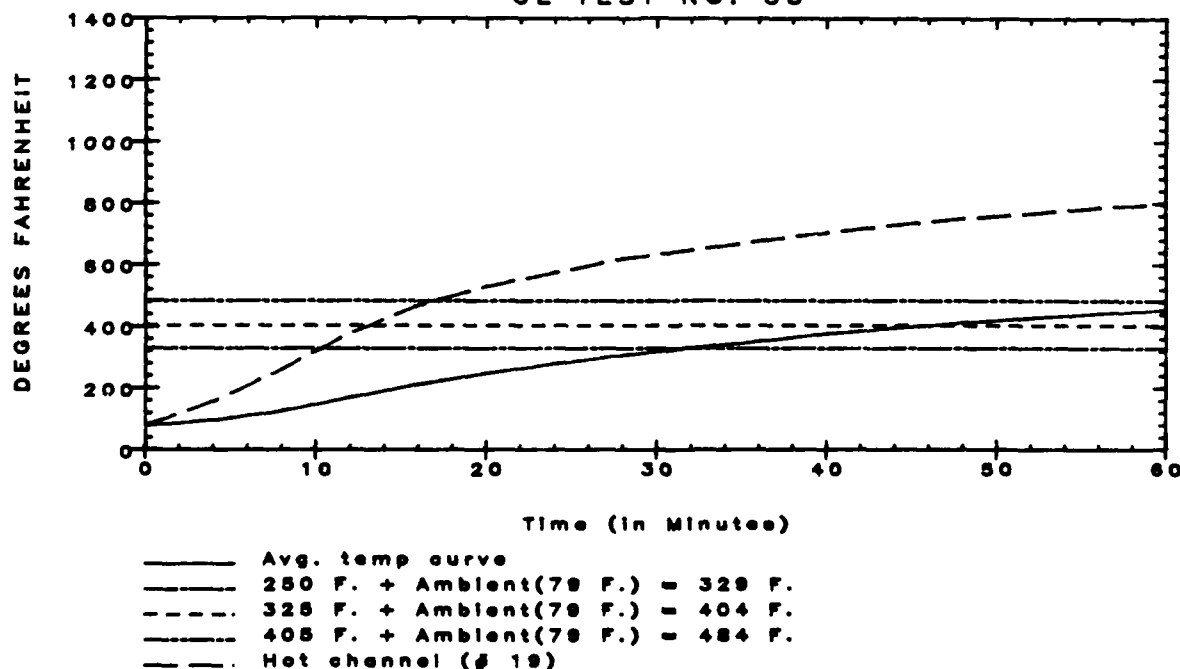
FILE USNC142
 ILL. 62C

U.S. COAST GUARD
 UL Test No. 35 - D19/A60-6E
 86NK8673/USNC142
 6-26-86

Temperature Degrees F

| CHAN(NOS.) | 18 | 19 | 20 | 21 | 22 |
|------------|-------|-------|-------|--------|--------|
| TIME | | | | | |
| 0: 0 | 78.0 | 79.7 | 78.9 | 80.4 | 79.4 |
| 4: 0 | 90.7 | 157.0 | 116.7 | 371.8 | 278.9 |
| 8: 0 | 124.6 | 261.4 | 184.9 | 651.8 | 469.7 |
| 12: 0 | 174.8 | 378.6 | 275.9 | 879.7 | 663.2 |
| 16: 0 | 227.8 | 469.2 | 358.0 | 1012.1 | 801.2 |
| 20: 0 | 276.5 | 530.3 | 416.5 | 1078.4 | 872.0 |
| 24: 0 | 318.7 | 574.9 | 459.2 | 1129.4 | 916.0 |
| 28: 0 | 354.2 | 620.2 | 493.2 | 1201.4 | 962.1 |
| 32: 0 | 385.9 | 647.4 | 521.4 | 1245.7 | 995.0 |
| 36: 0 | 414.0 | 677.2 | 546.9 | 1295.3 | 1031.4 |
| 40: 0 | 440.5 | 705.6 | 571.6 | 1340.5 | 1061.1 |
| 44: 0 | 464.6 | 730.1 | 595.1 | 1373.0 | 1081.8 |
| 48: 0 | 487.6 | 751.9 | 614.6 | 1396.2 | 1103.3 |
| 52: 0 | 506.1 | 767.4 | 632.3 | 1413.8 | 1123.6 |
| 56: 0 | 525.1 | 787.1 | 647.3 | 1428.2 | 1137.0 |
| 60: 0 | 542.5 | 799.4 | 662.2 | 1438.1 | 1150.8 |

SAMPLE D19/A60-6E
 UL TEST NO. 35



T E S T R E C O R D D19/A60-6USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D19/A60-6U and as shown in ILL. 63.

The fire and hose stream tests were conducted on June 25, 1986 and identified by UL as Test No. 34.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min(s)</u> | <u>Observations</u> |
|--------------------------|---|
| 0.08 (5) | The cables ignited on exposed side. |
| 0.16 (10) | Smoke issued from the periphery. |
| 5 | The steel plate bowed downward and was turning black in color. |
| 6 | Light smoke issued from the interface of the steel plate and transit insulation. |
| 10 | Smoke issued from the interface of the transit insulation and the cables. |
| 22 | The transit insulation at the interface of the cables was turning black in color. |
| 40 | The cable jackets were melting at the interface of the transit insulation. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 64.

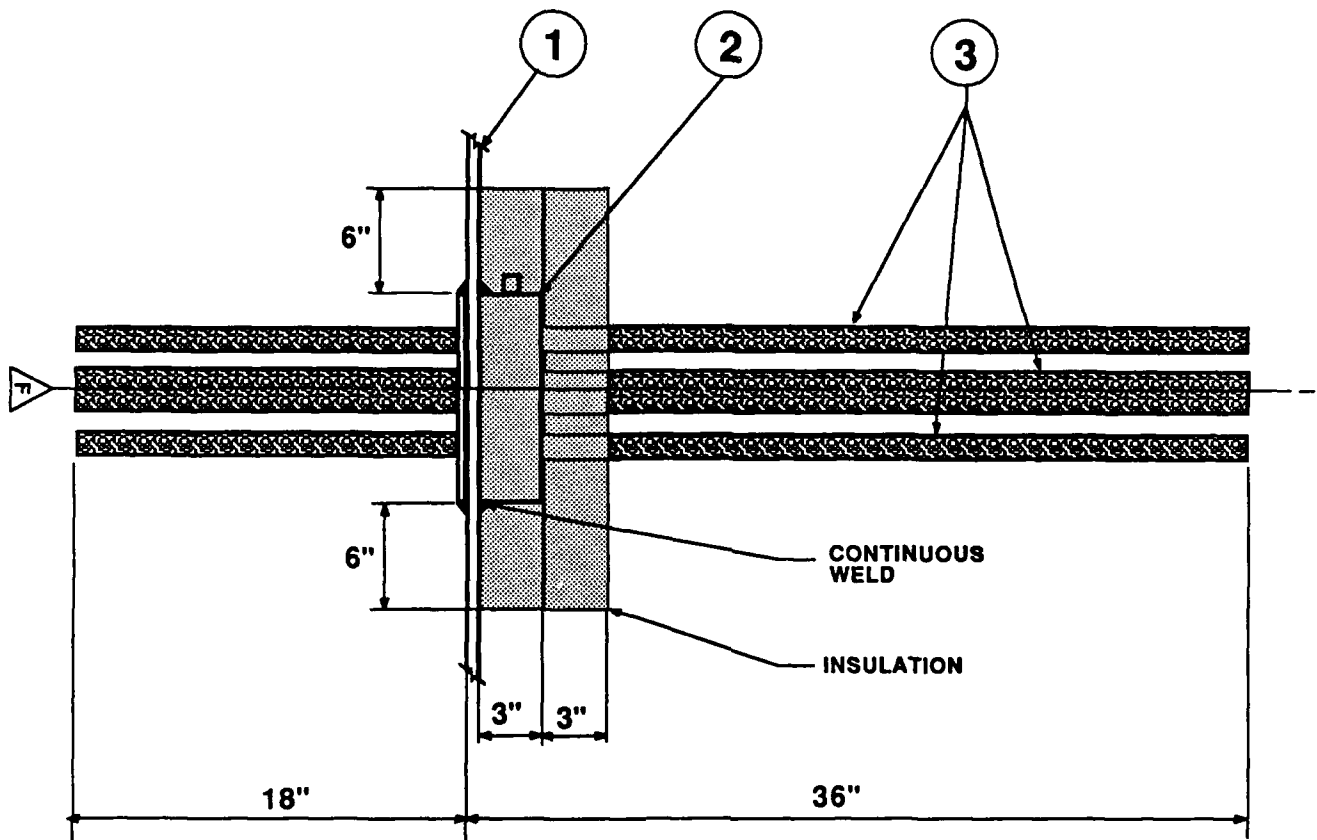
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 65 through 65C.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- 1 STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- 2 STEEL MULTI-CABLE TRANSIT.
- 3 VARIOUS SIZES OF ELECTRICAL (MARINE) CABLES,
CCG APPROVED (MINIMUM OF SIX (6) CABLES).



**TEST SAMPLE D-19A ELECTRICAL
CABLES IN MULTI-CABLE TRANSIT**
(R&DC GRAPHIC 33)

USNC 142
ILL. 63

SAMPLE D19/A60-6U
TEST DATE JUNE 25, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | At interface of transit insulation and steel plate. |
| 2 | At interface of transit insulation and steel plate. |
| 3 | On transit insulation, 3 in. from edge of transit insulation. |
| 4 | On transit insulation, 3 in. from edge of transit insulation. |
| 5 | On Type 1 cable, 6 in. from steel plate. |
| 6 | On Type 1 cable, 12 in. from steel plate. |
| 7 | On Type 1 cable, 18 in. from steel plate. |
| 8 | On Type 1 cable, 24 in. from steel plate. |
| 9 | On Type 2 cable, 6 in. from steel plate. |
| 10 | On Type 2 cable, 12 in. from steel plate. |
| 11 | On Type 2 cable, 18 in. from steel plate. |
| 12 | On Type 2 cable, 24 in. from steel plate. |
| 13 | On Type 3 cable, 6 in. from steel plate. |
| 14 | On Type 3 cable, 12 in. from steel plate. |
| 15 | On Type 3 cable, 18 in. from steel plate. |
| 16 | On Type 3 cable, 24 in. from steel plate |

Type 1 cable = 16 AWG Canada Wire Marinex X1 750 VT.
Type 2 cable = 6 AWG/3 Canada Wire Marinex X1 750 VT.
Type 3 cable = E67179 16 AWG 300 VT. Power limited circuit cable
Class 2 or 3, Type PLTC.

USNC142
ILL. 64

U.S. COAST GUARD
 UL Test No. 34 - D19/A60-6U
 86NK8673/USNC142
 6-25-86

| | Temperature Degrees F | | | |
|------------|-----------------------|--------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 128.6 | 127.3 | 76.5 | 76.5 |
| 8: 0 | 1143.2 | 1131.7 | 78.0 | 81.2 |
| 12: 0 | 1252.0 | 1236.0 | 82.4 | 89.1 |
| 16: 0 | 1310.4 | 1304.2 | 87.6 | 99.5 |
| 20: 0 | 1354.7 | 1360.7 | 98.0 | 114.5 |
| 24: 0 | 1391.0 | 1407.8 | 112.8 | 128.5 |
| 28: 0 | 1427.0 | 1459.8 | 176.0 | 166.2 |
| 32: 0 | 1449.8 | 1495.0 | 167.6 | 176.5 |
| 36: 0 | 1485.8 | 1513.8 | 167.3 | 193.0 |
| 40: 0 | 1500.8 | 1516.6 | 168.4 | 259.1 |
| 44: 0 | 1530.6 | 1543.8 | 197.0 | 514.3 |
| 48: 0 | 1555.1 | 1568.5 | 422.5 | 753.4 |
| 52: 0 | 1574.0 | 1595.3 | 748.9 | 692.0 |
| 56: 0 | 1604.5 | 1608.0 | 765.7 | 613.2 |
| 60: 0 | 1614.9 | 1613.0 | 713.3 | 587.7 |

FILE USNC142
 ILL. 65

U.S. COAST GUARD
 UL Test No. 34 - D19/A60-6U
 86NK8673/USNC142
 6-25-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NDS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 80.5 | 74.9 | 74.9 | 75.1 |
| 8: 0 | 94.0 | 83.8 | 86.2 | 88.2 |
| 12: 0 | 117.9 | 95.5 | 98.4 | 102.0 |
| 16: 0 | 155.7 | 111.5 | 112.3 | 117.9 |
| 20: 0 | 200.5 | 130.4 | 126.3 | 131.8 |
| 24: 0 | 247.3 | 151.3 | 139.7 | 144.4 |
| 28: 0 | 287.9 | 172.4 | 152.7 | 156.3 |
| 32: 0 | 324.2 | 192.8 | 163.9 | 167.3 |
| 36: 0 | 354.5 | 206.5 | 177.7 | 178.3 |
| 40: 0 | 379.2 | 223.7 | 188.4 | 187.3 |
| 44: 0 | 396.7 | 235.5 | 195.6 | 195.8 |
| 48: 0 | 420.0 | 257.4 | 210.7 | 206.5 |
| 52: 0 | 445.7 | 275.3 | 219.8 | 213.0 |
| 56: 0 | 480.7 | 291.1 | 230.2 | 221.0 |
| 60: 0 | 518.2 | 305.5 | 241.5 | 229.3 |

FILE USNC142
 ILL. 65A

U.S. COAST GUARD
 UL Test No. 34 - D19/A60-6U
 86NK8673/USNC142
 6-25-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 82.5 | 76.0 | 75.2 | 74.8 |
| 8: 0 | 106.8 | 91.6 | 87.4 | 84.0 |
| 12: 0 | 142.3 | 110.0 | 100.0 | 94.2 |
| 16: 0 | 193.6 | 132.5 | 114.2 | 105.2 |
| 20: 0 | 249.2 | 156.8 | 128.8 | 116.7 |
| 24: 0 | 309.7 | 185.2 | 143.0 | 127.2 |
| 28: 0 | 365.4 | 210.1 | 156.5 | 137.0 |
| 32: 0 | 418.3 | 229.4 | 169.0 | 145.5 |
| 36: 0 | 455.4 | 251.4 | 183.1 | 155.1 |
| 40: 0 | 488.5 | 268.6 | 197.9 | 163.6 |
| 44: 0 | 518.1 | 282.7 | 205.0 | 170.0 |
| 48: 0 | 550.2 | 304.2 | 212.3 | 179.8 |
| 52: 0 | 579.4 | 319.4 | 221.3 | 187.1 |
| 56: 0 | 621.5 | 332.6 | 230.6 | 194.4 |
| 60: 0 | 657.5 | 352.7 | 238.5 | 200.6 |

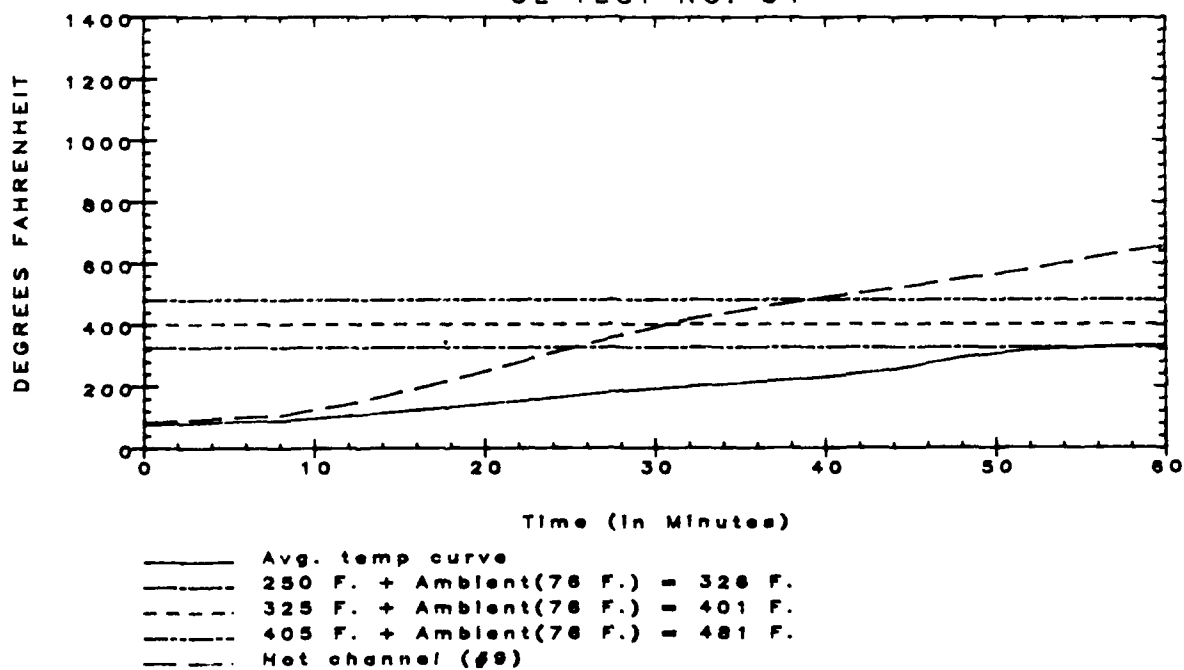
FILE USNC142
 ILL. 65E

U.S. COAST GUARD
 UL Test No. 34 - D19/A60-6U
 86NK8673/USNC142
 6-25-86

Temperature Degrees F

| CHAN(NOS.) | 13 | 14 | 15 | 16 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 78.0 | 76.1 | 73.9 | 73.8 |
| 8: 0 | 96.2 | 91.7 | 90.4 | 80.6 |
| 12: 0 | 120.8 | 109.3 | 108.8 | 105.2 |
| 16: 0 | 156.2 | 129.1 | 125.4 | 119.3 |
| 20: 0 | 190.4 | 148.0 | 140.1 | 131.8 |
| 24: 0 | 216.7 | 165.0 | 153.1 | 142.5 |
| 28: 0 | 238.5 | 180.6 | 164.1 | 151.9 |
| 32: 0 | 260.1 | 191.2 | 172.3 | 160.4 |
| 36: 0 | 285.0 | 203.8 | 183.5 | 169.3 |
| 40: 0 | 307.3 | 214.4 | 191.1 | 176.5 |
| 44: 0 | 330.0 | 218.7 | 193.8 | 180.6 |
| 48: 0 | 368.4 | 235.6 | 207.0 | 190.7 |
| 52: 0 | 453.6 | 249.4 | 215.9 | 197.5 |
| 56: 0 | 498.7 | 257.9 | 221.0 | 203.4 |
| 60: 0 | 543.6 | 267.5 | 227.9 | 210.5 |

SAMPLE D19/A60-6U
 UL TEST NO. 34



T E S T R E C O R D D19/A60-3E&3USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D19/A60-3E&3U and as shown in ILL. 66.

The fire and hose stream tests were conducted on June 23, 1986 and identified by UL as Test No. 29.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|--|
| 0.5 | The cables ignited on the exposed side. |
| 3 | The cables on the exposed side were heavily charred. |
| 5 | Smoke issued from the periphery. The steel plate turned black in color and was twisting at its center. |
| 11 | Mineral wool insulation was placed on the periphery of the steel plate due to heavy buckling of the steel plate which caused a small opening into the furnace chamber. |
| 30 | The steel plate was glowing red. |
| 40 | Light smoke issued from the cables at the interface of the cables and transit insulation. |
| 45 | The smoke intensity increased off of the cables. Flames began to issue from under the transit insulation. |
| 50 | The smoke intensity increased off of the cables. |
| 55 | The cable jackets were melting at the interface of the cables and transit insulation. A flash of flame was visible on a cable jacket near the transit insulation. |
| 60 | Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILLS. 67 through 67A.

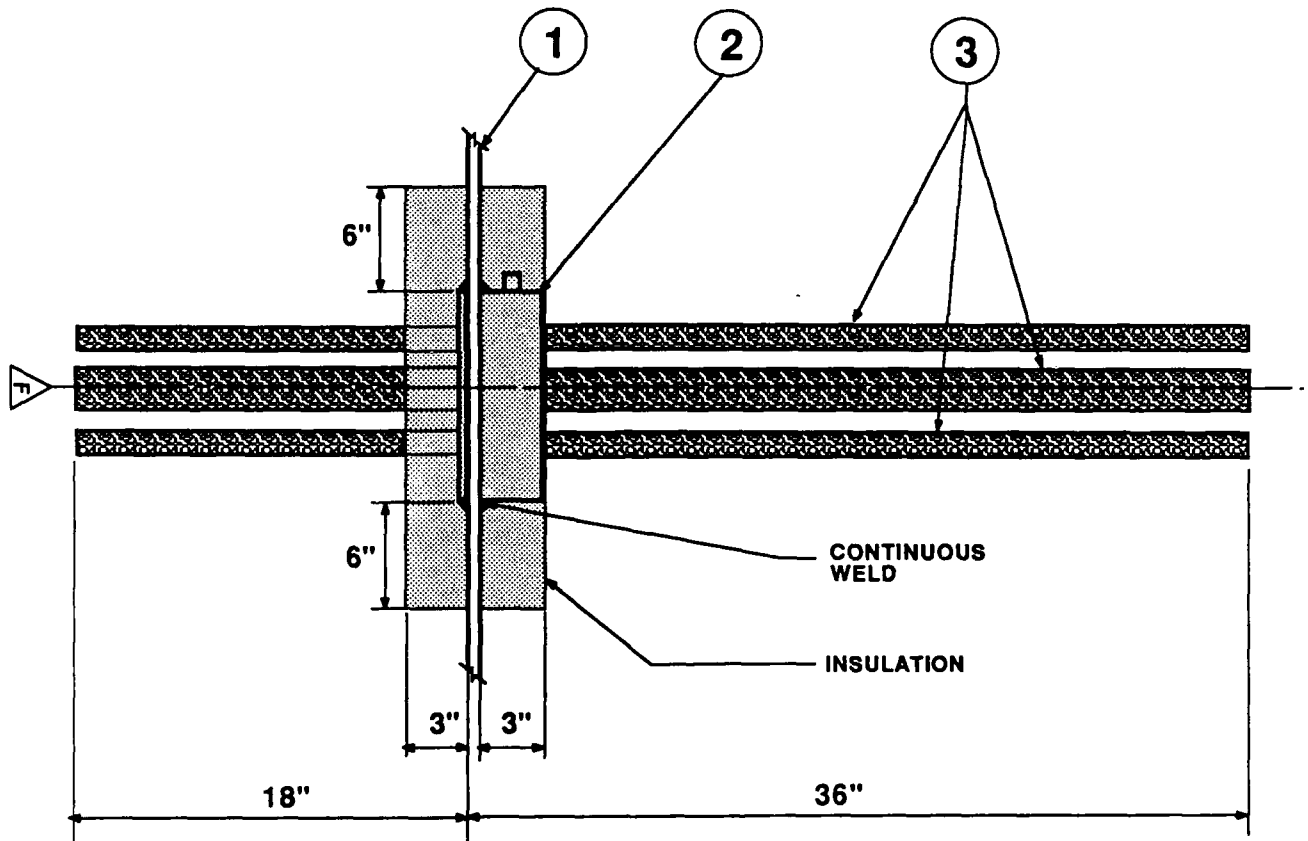
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 68 through 68D. Thermocouple No. 12 was inoperable until 20 min into the fire test.

HOSE STREAM TEST:

A very small amount of water passed through the assembly at the interface of the transit and cable insulations during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② STEEL MULTI-CABLE TRANSIT.
- ③ VARIOUS SIZES OF ELECTRICAL (MARINE) CABLES,
CCG APPROVED (MINIMUM OF SIX (6) CABLES).



TEST SAMPLE D-19A ELECTRICAL
CABLES IN MULTI-CABLE TRANSIT
(R&DC GRAPHIC 34)

USNC 142
ILL. 66

SAMPLE D19/A60-3E&3U
TEST DATE JUNE 23, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | At interface of steel plate and transit insulation. |
| 2 | At interface of steel plate and transit insulation. |
| 3 | On transit insulation, 3 in. from edge of transit insulation. |
| 4 | On transit insulation, 3 in. from edge of transit insulation. |
| 5 | On Type 1 cable, 3 in. from steel plate. |
| 6 | On Type 1 cable, 6 in. from steel plate. |
| 7 | On Type 1 cable, 12 in. from steel plate. |
| 8 | On Type 1 cable, 18 in. from steel plate. |
| 9 | On Type 1 cable, 24 in. from steel plate. |
| 10 | On Type 2 cable, 3 in. from steel plate. |
| 11 | On Type 2 cable, 6 in. from steel plate. |
| 12 | On Type 2 cable, 12 in. from steel plate. |
| 13 | On Type 2 cable, 18 in. from steel plate. |
| 14 | On Type 2 cable, 24 in. from steel plate. |
| 15 | On Type 3 cable, 3 in. from steel plate. |
| 16 | On Type 3 cable, 6 in. from steel plate. |
| 17 | On Type 3 cable, 12 in. from steel plate. |

USNC142
ILL. 67

| <u>T.C.</u> | <u>Location</u> |
|----------------|---|
| 18 | On Type 3 cable, 18 in. from steel plate. |
| 19 | On Type 3 cable, 24 in. from steel plate. |
| Type 1 cable = | 8 SHLD Pair/16 AWG Canada Wire Marinex X1 300 Volts. |
| Type 2 cable = | 6 AWG/3 Canada Marinex X1 750 Volts. |
| Type 3 cable = | E67179 16 AWG 300 V Power Limited Circuit cable Class 2 or 3 Type PLTC |

USNC142
ILL. 67A

U.S. COAST GUARD
 UL Test No. 29 - D19/A60-3E&3U
 86NK8673/USNC142
 6-23-86

| | Temperature Degrees F | | | |
|------------|-----------------------|--------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 78.9 | 78.7 | 78.6 | 79.8 |
| 4: 0 | 246.0 | 80.5 | 79.5 | 79.2 |
| 8: 0 | 769.9 | 455.6 | 83.0 | 84.5 |
| 12: 0 | 944.0 | 608.0 | 88.6 | 92.2 |
| 16: 0 | 1099.9 | 773.3 | 94.8 | 107.9 |
| 20: 0 | 1186.5 | 886.3 | 105.1 | 130.9 |
| 24: 0 | 1247.7 | 963.8 | 120.0 | 157.6 |
| 29: 0 | 1340.8 | 1055.9 | 154.1 | 200.9 |
| 32: 0 | 1395.5 | 1090.9 | 177.7 | 223.0 |
| 36: 0 | 1459.4 | 1132.9 | 214.7 | 252.2 |
| 40: 0 | 1518.6 | 1172.2 | 266.9 | 283.8 |
| 44: 0 | 1561.5 | 1204.2 | 329.6 | 311.0 |
| 48: 0 | 1594.1 | 1235.0 | 408.8 | 341.5 |
| 52: 0 | 1619.7 | 1259.3 | 491.3 | 373.3 |
| 56: 0 | 1644.7 | 1276.8 | 557.6 | 407.0 |
| 60: 0 | 1666.9 | 1295.5 | 637.4 | 448.6 |

FILE USNC142
 ILL. 68

U.S. COAST GUARD
 UL Test No. 29 - D19/A60-3E&3U
 86NK8673/USNC142
 6-23-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 78.7 | 77.7 | 78.0 | 78.0 |
| 4: 0 | 80.4 | 81.6 | 84.6 | 82.7 |
| 8: 0 | 89.2 | 87.1 | 96.9 | 91.8 |
| 12: 0 | 104.7 | 98.2 | 113.5 | 103.6 |
| 16: 0 | 134.6 | 116.8 | 138.8 | 123.6 |
| 20: 0 | 170.5 | 139.5 | 161.0 | 141.4 |
| 24: 0 | 197.4 | 162.5 | 180.8 | 157.4 |
| 29: 0 | 234.3 | 192.0 | 205.5 | 177.3 |
| 32: 0 | 253.4 | 201.8 | 218.0 | 187.0 |
| 36: 0 | 277.4 | 216.3 | 228.4 | 198.3 |
| 40: 0 | 303.3 | 232.9 | 243.5 | 209.2 |
| 44: 0 | 328.8 | 251.9 | 257.9 | 216.0 |
| 48: 0 | 359.5 | 265.8 | 273.7 | 228.6 |
| 52: 0 | 400.3 | 287.7 | 290.0 | 240.2 |
| 56: 0 | 443.4 | 308.8 | 302.5 | 249.4 |
| 60: 0 | 480.0 | 331.1 | 316.0 | 258.2 |

FILE USNC142
 ILL. 68A

U.S. COAST GUARD
 UL Test No. 29 - D19/A60-3E&3U
 86NK8673/USNC142
 6-23-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 79.1 | 78.7 | 79.0 | ---- |
| 4: 0 | 82.2 | 85.3 | 82.1 | ---- |
| 8: 0 | 90.3 | 107.4 | 94.3 | ---- |
| 12: 0 | 100.5 | 139.7 | 114.5 | ---- |
| 16: 0 | 115.7 | 190.5 | 148.8 | ---- |
| 20: 0 | 129.3 | 233.9 | 193.5 | 163.0 |
| 24: 0 | 141.1 | 275.9 | 212.9 | 185.6 |
| 29: 0 | 156.8 | 337.8 | 255.0 | 214.5 |
| 32: 0 | 164.1 | 367.5 | 272.1 | 222.8 |
| 36: 0 | 171.1 | 410.1 | 292.6 | 236.7 |
| 40: 0 | 179.3 | 436.3 | 315.2 | 250.8 |
| 44: 0 | 187.6 | 468.6 | 342.8 | 265.6 |
| 48: 0 | 197.6 | 498.0 | 366.3 | 281.0 |
| 52: 0 | 205.7 | 524.6 | 383.4 | 293.5 |
| 56: 0 | 211.2 | 546.0 | 395.9 | 304.3 |
| 60: 0 | 215.2 | 573.7 | 410.3 | 314.5 |

FILE USNC142
 ILL. 688

U.S. COAST GUARD
 UL Test No. 29 - D19/A60-3E&3U
 86NK8673/USNC142
 6-23-86

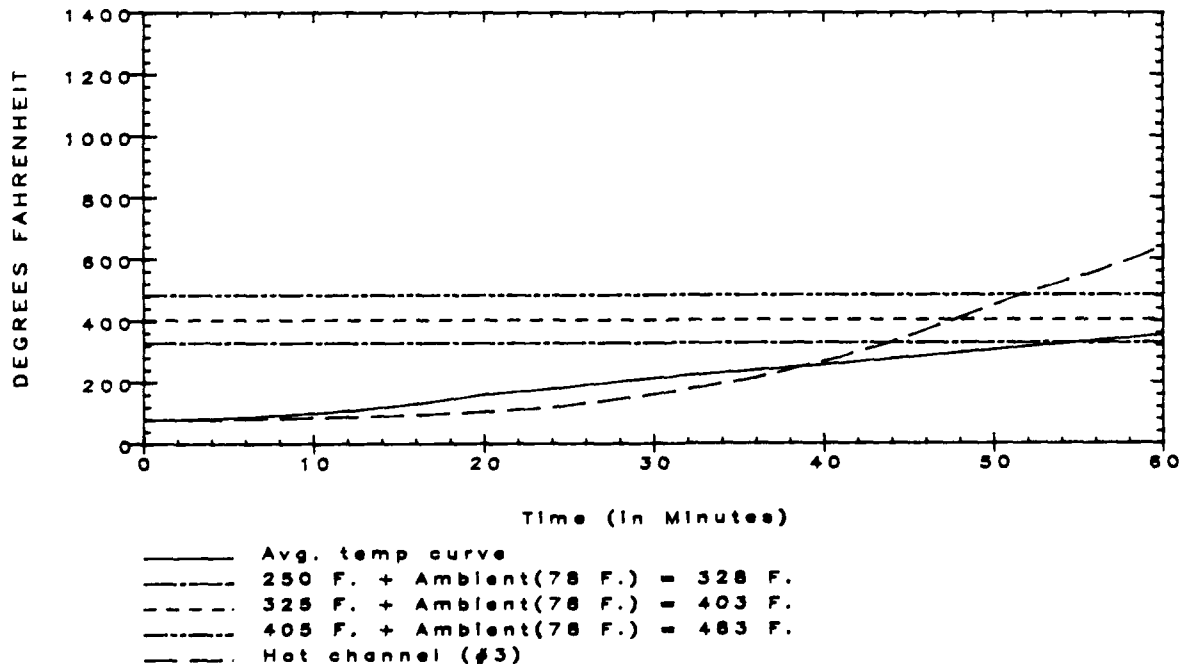
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 13 | 14 | 15 | 16 |
| TIME | | | | |
| 0: 0 | 78.0 | 79.1 | 77.7 | 77.8 |
| 4: 0 | 74.3 | 83.6 | 86.1 | 83.6 |
| 8: 0 | 97.1 | 93.6 | 105.2 | 96.0 |
| 12: 0 | 114.3 | 107.7 | 130.1 | 122.5 |
| 16: 0 | 135.9 | 123.0 | 177.8 | 145.4 |
| 20: 0 | 154.3 | 136.3 | 202.3 | 179.3 |
| 24: 0 | 170.9 | 148.1 | 215.2 | 198.7 |
| 29: 0 | 193.5 | 163.1 | 254.3 | 209.3 |
| 32: 0 | 212.7 | 170.4 | 273.8 | 221.3 |
| 36: 0 | 214.8 | 179.4 | 299.8 | 236.6 |
| 40: 0 | 216.9 | 189.0 | 327.4 | 251.8 |
| 44: 0 | 230.2 | 202.6 | 359.7 | 265.9 |
| 48: 0 | 239.8 | 205.0 | 385.8 | 287.4 |
| 52: 0 | 249.4 | 207.7 | 412.3 | 307.7 |
| 56: 0 | 257.0 | 209.5 | 434.2 | 325.3 |
| 60: 0 | 266.0 | 213.0 | 463.3 | 342.5 |

FILE USNC142
 ILL. 68C

U.S. COAST GUARD
 UL Test No. 29 - D19/A60-3E&U
 86NK8673/USNC142
 6-23-86

| | Temperature Degrees F | | |
|------------|-----------------------|-------|-------|
| CHAN(NOS.) | 17 | 18 | 19 |
| TIME | | | |
| 0: 0 | 77.9 | 78.0 | 78.0 |
| 4: 0 | 84.6 | 86.0 | 85.7 |
| 8: 0 | 100.7 | 103.7 | 100.7 |
| 12: 0 | 121.2 | 124.2 | 119.2 |
| 16: 0 | 149.1 | 149.2 | 136.6 |
| 20: 0 | 172.1 | 168.1 | 151.2 |
| 24: 0 | 190.4 | 181.5 | 161.3 |
| 29: 0 | 214.7 | 212.9 | 178.1 |
| 32: 0 | 219.2 | 217.3 | 188.4 |
| 36: 0 | 225.1 | 217.2 | 195.6 |
| 40: 0 | 235.5 | 221.6 | 201.9 |
| 44: 0 | 246.7 | 228.6 | 206.4 |
| 48: 0 | 260.8 | 235.9 | 212.1 |
| 52: 0 | 272.2 | 243.7 | 214.2 |
| 56: 0 | 283.6 | 252.8 | 215.7 |
| 60: 0 | 292.4 | 261.7 | 221.2 |

SAMPLE D19/A60 - 3E&3U
 UL TEST NO. 29



T E S T R E C O R D D21/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D21/A60U and as shown in ILL. 69.

The fire and hose stream tests were conducted on June 26, 1986 and identified by UL as Test No. 36.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|---|
| 31 | The steel plate along with the insulation is bowing downward. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 70.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 71 through 71B.

HOSE STREAM TEST:

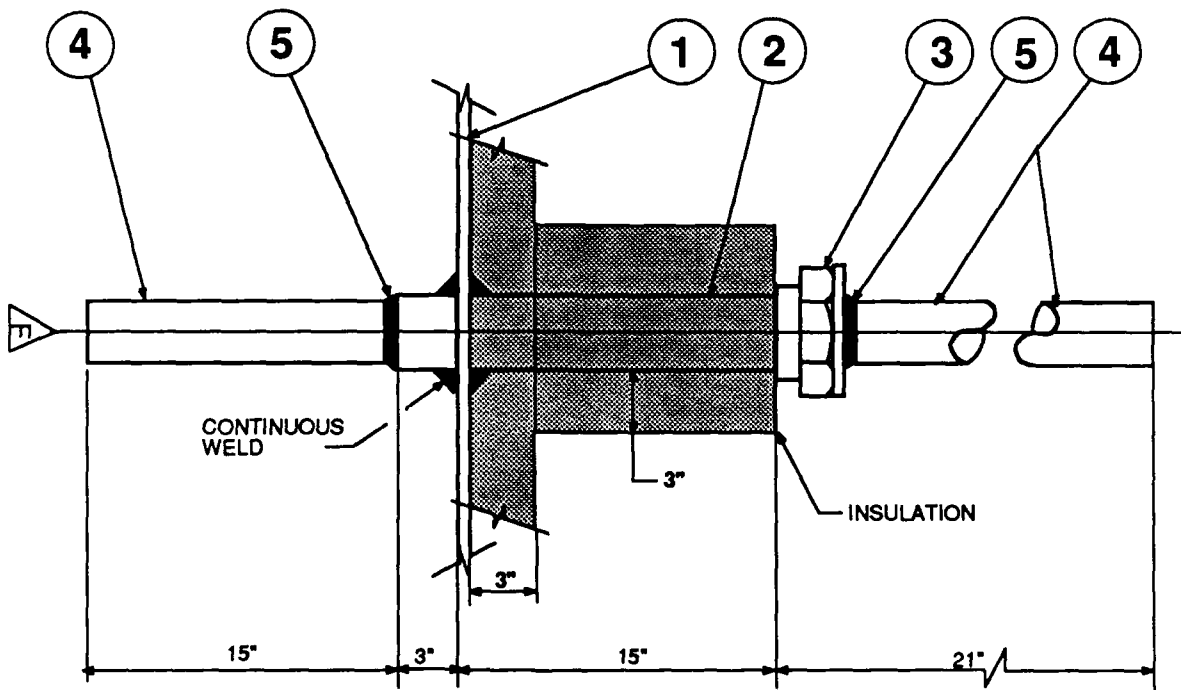
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D21/A60U
UL TEST NO. 36

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIA. SCHEDULE 40.
- ③ BRASS TERMINAL TUBE, "KONDU" TYPE
V-200 FP WITH PILOT HOLE DRILLED TO
SUIT ELECTRICAL CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL
CABLE, APPROX 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT.



TEST SAMPLE NO. D-21A
ELECTRICAL CABLE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE

(N&DC GRAPHIC 36)

USNC 142
ILL. 69

SAMPLE D21/A60U
TEST DATE JUNE 26, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | At interface of penetrant insulation and steel plate insulation. |
| 2 | On penetrant, 4 in. above steel plate. |
| 3 | On penetrant, 6 in. above steel plate. |
| 4 | On penetrant, 12 in. above steel plate. |
| 5 | At interface of brass terminal tube and cable. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate insulation, 6 in. from penetrant. |
| 8 | On steel plate insulation seam, 6 in. from penetrant. |
| 9 | On steel plate insulation, 12 in. from penetrant. |
| 10 | On steel plate insulation seam, 12 in. from penetrant. |
| 11 | On top of cable, on copper conductor. |

USNC142
ILL. 70

U.S. COAST GUARD
 UL Test No. 36 - D21/A60U
 86NK8673/USNC142
 6-26-86

Temperature Degrees F

| CHAN(NDS.) | 1 | 2 | 3 | 4 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 92.4 | 89.5 | 90.1 | 90.1 |
| 4: 0 | 93.1 | 90.4 | 90.7 | 90.9 |
| 8: 0 | 94.7 | 92.5 | 92.5 | 92.9 |
| 12: 0 | 100.1 | 94.9 | 93.7 | 94.5 |
| 16: 0 | 108.1 | 97.7 | 96.1 | 97.0 |
| 20: 0 | 159.3 | 114.0 | 100.6 | 100.0 |
| 24: 0 | 294.0 | 159.6 | 109.6 | 105.6 |
| 28: 0 | 491.8 | 237.7 | 125.1 | 114.6 |
| 32: 0 | 595.1 | 315.3 | 141.8 | 124.0 |
| 36: 0 | 636.6 | 364.5 | 157.8 | 130.1 |
| 40: 0 | 659.6 | 393.6 | 172.0 | 135.3 |
| 44: 0 | 676.7 | 412.8 | 185.4 | 140.1 |
| 48: 0 | 692.2 | 428.2 | 198.8 | 144.9 |
| 52: 0 | 706.7 | 441.1 | 211.1 | 148.9 |
| 56: 0 | 722.5 | 454.3 | 223.3 | 154.2 |
| 60: 0 | 734.5 | 465.7 | 233.1 | 159.5 |

FILE USNC142
 ILL. 71

U.S. COAST GUARD
UL Test No. 36 - D21/A60U
86NK8673/USNC142
6-26-86

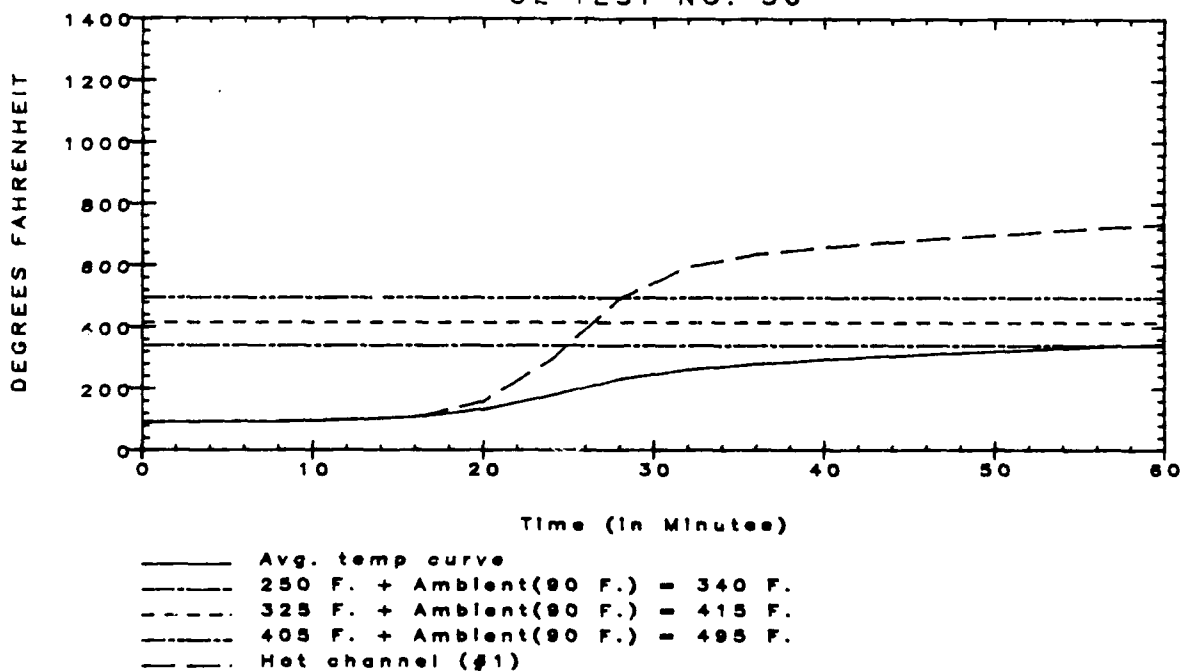
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NDS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 86.7 | 86.6 | 92.4 | 92.9 |
| 4: 0 | 87.1 | 92.4 | 92.4 | 105.3 |
| 8: 0 | 87.6 | 87.6 | 93.1 | 107.4 |
| 12: 0 | 89.1 | 89.6 | 95.8 | 142.8 |
| 16: 0 | 92.3 | 91.3 | 104.7 | 214.3 |
| 20: 0 | 96.6 | 93.8 | 146.4 | 327.4 |
| 24: 0 | 106.8 | 99.7 | 256.5 | 444.3 |
| 28: 0 | 123.7 | 108.1 | 376.7 | 506.1 |
| 32: 0 | 145.5 | 118.4 | 415.6 | 533.5 |
| 36: 0 | 172.7 | 130.9 | 434.3 | 555.1 |
| 40: 0 | 188.5 | 146.3 | 448.0 | 576.3 |
| 44: 0 | 198.0 | 164.6 | 458.6 | 595.6 |
| 48: 0 | 205.2 | 179.9 | 470.8 | 614.6 |
| 52: 0 | 212.6 | 187.2 | 480.6 | 630.7 |
| 56: 0 | 227.0 | 194.3 | 493.1 | 649.8 |
| 60: 0 | 244.3 | 200.9 | 500.0 | 660.0 |

FILE USNC142
ILL. 71A

U.S. COAST GUARD
UL Test No. 36 - D21/A60U
86NK8673/USNC142
6-26-86

| | Temperature Degrees F | | |
|------------|-----------------------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 |
| TIME | | | |
| 0: 0 | 88.0 | 93.3 | 87.9 |
| 4: 0 | 88.9 | 98.3 | 88.1 |
| 8: 0 | 89.2 | 96.1 | 89.0 |
| 12: 0 | 89.5 | 99.5 | 89.1 |
| 16: 0 | 90.2 | 104.7 | 89.0 |
| 20: 0 | 90.6 | 125.1 | 91.8 |
| 24: 0 | 90.9 | 169.6 | 93.6 |
| 28: 0 | 91.7 | 243.8 | 99.4 |
| 32: 0 | 92.2 | 278.2 | 104.7 |
| 36: 0 | 92.4 | 290.7 | 112.8 |
| 40: 0 | 92.0 | 297.0 | 123.0 |
| 44: 0 | 92.4 | 304.6 | 134.7 |
| 48: 0 | 92.5 | 307.3 | 146.6 |
| 52: 0 | 92.8 | 312.6 | 158.2 |
| 56: 0 | 92.0 | 318.6 | 169.2 |
| 60: 0 | 92.0 | 326.3 | 177.0 |

SAMPLE D21/A60U
UL TEST NO. 36



T E S T R E C O R D D22/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D22/A60E and as shown in ILL. 72.

The fire and hose stream tests were conducted on June 17, 1986 and identified by UL as Test No. 22.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|----------------------|
|-----------------------|----------------------|

| | |
|----|---|
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |
|----|---|

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 73.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 74 through 74B.

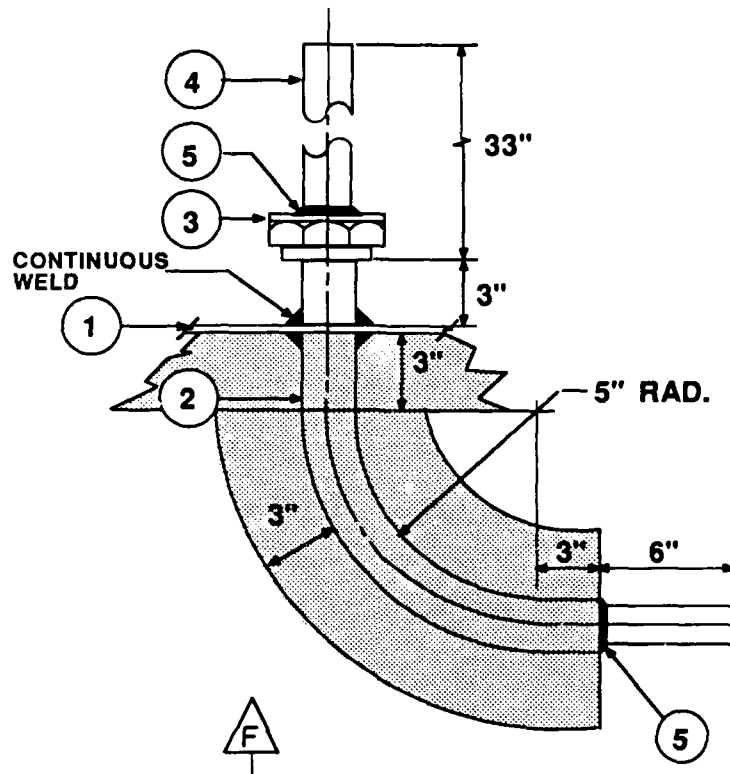
HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

D22/A60E
UL TEST NO. 22



- ① STEEL PLATE, 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIAMETER, SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE V-200 FP
WITH PILOT HOLE DRILLED TO SUIT ELECTRICAL CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL CABLE
APPROX. 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT

TEST SAMPLE NO. D-22A
ELECTRICAL CABLE
WITH STEEL SPIGOT AND
BRASS TERMINAL TUBE

(R&DC GRAPHICS 38)

USNC 142
ILL. 72

SAMPLE D22/A60E
TEST DATE JUNE 17, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On brass terminal tube (4 in. above steel plate). |
| 2 | On interface of steel pipe and cable (5-3/4 in. above steel plate). |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, 18 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | On steel plate over insulation, 3 in. from penetrant. |
| 7 | On steel plate over insulation, 6 in. from penetrant. |
| 8 | On steel plate over insulation seam, 6 in. from penetrant. |
| 9 | On steel plate over insulation, 12 in. from penetrant. |
| 10 | On steel plate over insulation seam, 12 in. from penetrant. |
| 11 | On top of cable, on copper conductor. |

Thermocouples 6-10 were located on the steel plate opposite of the insulation mass of the penetrant on the exposed side.
Reference ILL. 72.

USNC142
ILL. 73

U.S. COAST GUARD
 UL Test No. 22 - D22/A60E
 86NK8673/USNC142
 6-17-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 71.4 | 71.4 | 71.4 | 71.4 |
| 4: 0 | 72.9 | 71.8 | 71.6 | 70.4 |
| 8: 0 | 71.9 | 71.0 | 71.6 | 70.4 |
| 12: 0 | 72.4 | 72.5 | 71.0 | 70.8 |
| 16: 0 | 73.3 | 73.4 | 72.5 | 70.9 |
| 20: 0 | 75.3 | 75.4 | 73.9 | 72.0 |
| 24: 0 | 79.6 | 78.6 | 76.3 | 73.7 |
| 28: 0 | 111.1 | 84.0 | 79.3 | 73.9 |
| 32: 0 | 167.2 | 102.1 | 84.9 | 77.3 |
| 36: 0 | 172.3 | 122.7 | 92.2 | 80.2 |
| 40: 0 | 176.5 | 137.6 | 99.0 | 83.8 |
| 44: 0 | 182.3 | 151.4 | 108.3 | 89.6 |
| 48: 0 | 186.5 | 164.5 | 118.3 | 92.6 |
| 52: 0 | 191.3 | 173.9 | 128.4 | 98.2 |
| 56: 0 | 195.0 | 181.0 | 139.2 | 103.8 |
| 60: 0 | 199.7 | 190.4 | 152.4 | 110.8 |

FILE USNC142
 ILL. 74

U.S. COAST GUARD
UL Test No. 22 - D22/A60E
86NK8673/USNC142
6-17-86

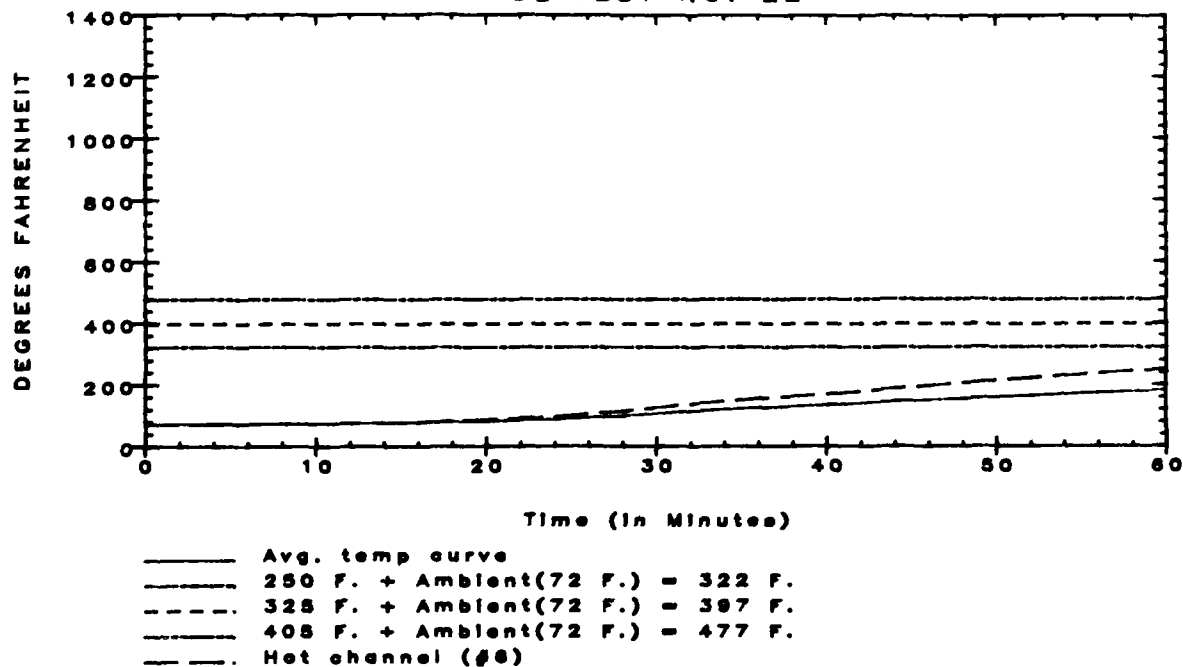
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 71.4 | 71.4 | 72.8 | 72.8 |
| 4: 0 | 71.4 | 71.5 | 72.9 | 72.0 |
| 8: 0 | 71.4 | 73.7 | 74.7 | 74.7 |
| 12: 0 | 70.5 | 75.4 | 77.7 | 77.2 |
| 16: 0 | 72.1 | 79.3 | 83.3 | 81.3 |
| 20: 0 | 72.2 | 86.7 | 91.5 | 87.7 |
| 24: 0 | 72.7 | 96.2 | 103.6 | 97.2 |
| 28: 0 | 72.3 | 113.7 | 120.9 | 111.9 |
| 32: 0 | 74.6 | 138.6 | 140.9 | 129.1 |
| 36: 0 | 75.0 | 154.8 | 158.2 | 142.8 |
| 40: 0 | 77.5 | 169.2 | 173.4 | 151.1 |
| 44: 0 | 79.8 | 187.7 | 192.0 | 163.4 |
| 48: 0 | 82.7 | 205.3 | 208.5 | 176.0 |
| 52: 0 | 85.8 | 221.5 | 223.0 | 186.8 |
| 56: 0 | 88.9 | 236.8 | 236.3 | 197.0 |
| 60: 0 | 92.9 | 252.1 | 248.8 | 208.9 |

FILE USNC142
ILL. 74A

U.S. COAST GUARD
 UL Test No. 22 - D22/A60E
 86NK8673/USNC142
 6-17-86

| | Temperature Degrees F | | |
|------------|-----------------------|-------|------|
| CHAN(NDS.) | 9 | 10 | 11 |
| TIME | | | |
| 0: 0 | 72.8 | 73.1 | 71.4 |
| 4: 0 | 74.3 | 75.6 | 71.5 |
| 8: 0 | 76.4 | 77.5 | 71.6 |
| 12: 0 | 80.3 | 80.8 | 72.0 |
| 16: 0 | 85.2 | 86.6 | 73.3 |
| 20: 0 | 92.0 | 93.6 | 73.7 |
| 24: 0 | 104.0 | 102.2 | 73.1 |
| 28: 0 | 119.0 | 115.0 | 73.7 |
| 32: 0 | 135.0 | 129.1 | 74.6 |
| 36: 0 | 149.7 | 142.8 | 75.6 |
| 40: 0 | 163.2 | 154.7 | 76.9 |
| 44: 0 | 177.6 | 179.7 | 78.7 |
| 48: 0 | 192.0 | 180.9 | 81.3 |
| 52: 0 | 205.5 | 194.1 | 83.3 |
| 56: 0 | 217.2 | 206.0 | 85.8 |
| 60: 0 | 228.2 | 218.3 | 89.4 |

SAMPLE D22/A60E
 UL TEST NO. 22



T E S T R E C O R D D22/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D22/A60U and as shown in ILL. 75.

The fire and hose stream tests were conducted on June 25, 1986 and identified by UL as Test No. 33.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|--|
| 6 | The steel plate and insulation bowed upward. |
| 10 | Smoke issued from the top of the cable. |
| 14 | The smoke stopped issuing from the top of the cable. |
| 30 | The steel plate and insulation receded. |
| 50 | Smoke issued from the interface of the penetrant insulation and steel plate insulation. The insulation in this area turned black in color. |
| 57 | Smoke issued from the first seam of the penetrant insulation (6 in. above steel plate). The insulation in this area turned black in color. |
| 60 | Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 76.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 77 through 77B.

Pressure Record - At the start of the fire endurance test, the pressure within the small-scale test furnace was -0.005 in./H₂O (-1.24 Pa). Throughout the remainder of the test, the pressure ranged from +0.005 in./H₂O to +0.01 in./H₂O (+1.24 Pa to +2.5 Pa).

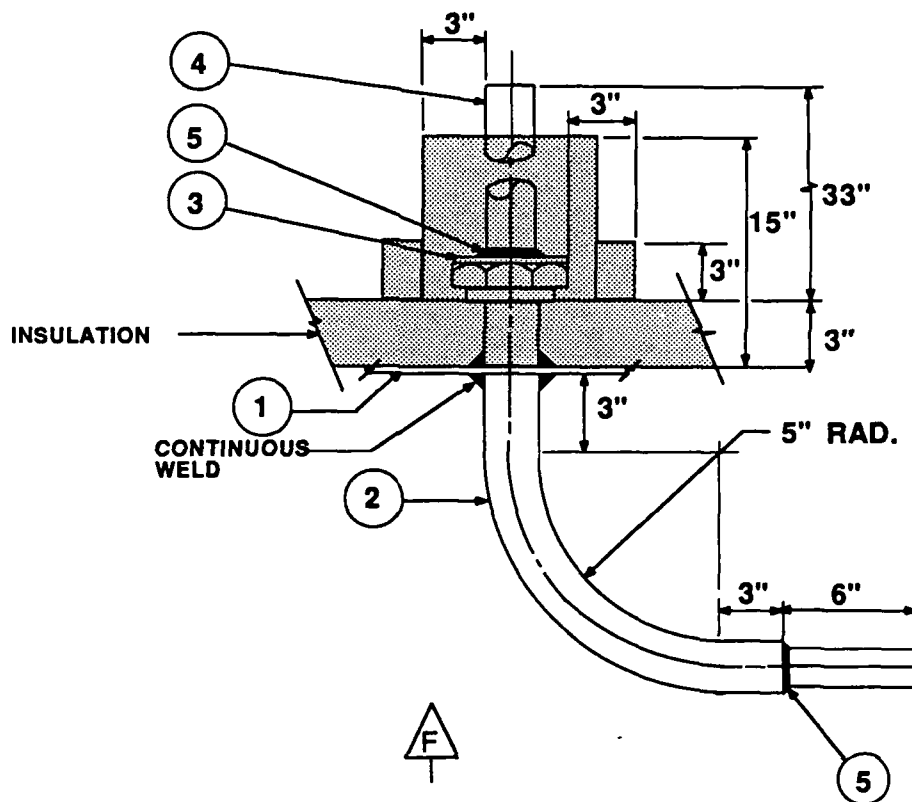
- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D22/A60U
UL TEST NO. 33



- ① STEEL PLATE, 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIAMETER, SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE V-200 FP
WITH PILOT HOLE DRILLED TO SUIT ELECTRICAL CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL CABLE
APPROX. 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT.

TEST SAMPLE NO. D-22A
ELECTRICAL CABLE
WITH STEEL SPIGOT AND
BRASS TERMINAL TUBE
(RADC GRAPHICS 37)

USNC 142
ILL. 75

SAMPLE D22/A60U
TEST DATE JUNE 25, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 5-3/4 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, 18 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | At interface of steel plate insulation and penetrant insulation. |
| 7 | On steel plate insulation, 6 in. from penetrant. |
| 8 | On steel plate insulation seam, 6 in. from penetrant. |
| 9 | On steel plate insulation, 12 in. from penetrant. |
| 10 | On steel plate insulation seam, 12 in. from penetrant. |
| 11 | On top of cable, on copper conductor. |

USNC142
ILL. 76

U.S. COAST GUARD
 UL Test No. 33 - D22/A60U
 86NK8673/USNC142
 6-25-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 71.1 | 71.2 | 70.8 | 69.5 |
| 4: 0 | 71.5 | 71.2 | 71.1 | 69.8 |
| 8: 0 | 72.7 | 71.9 | 72.1 | 71.4 |
| 12: 0 | 74.6 | 73.1 | 73.0 | 73.6 |
| 16: 0 | 83.6 | 77.1 | 76.1 | 76.9 |
| 20: 0 | 89.2 | 79.0 | 78.5 | 80.7 |
| 24: 0 | 93.5 | 82.7 | 81.1 | 89.9 |
| 28: 0 | 106.4 | 84.9 | 85.2 | 99.9 |
| 32: 0 | 147.1 | 88.7 | 91.4 | 113.9 |
| 36: 0 | 198.9 | 95.5 | 109.2 | 130.3 |
| 40: 0 | 243.5 | 104.1 | 102.6 | 148.9 |
| 44: 0 | 282.4 | 115.2 | 107.1 | 165.3 |
| 48: 0 | 314.0 | 129.7 | 112.1 | 172.2 |
| 52: 0 | 344.9 | 145.4 | 116.9 | 177.8 |
| 56: 0 | 391.9 | 166.6 | 122.0 | 184.4 |
| 60: 0 | 450.9 | 200.0 | 127.0 | 190.5 |

FILE USNC142
 ILL. 77

U.S. COAST GUARD
 UL Test No. 33 - D22/A60U
 86NK8673/USNC142
 6-25-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 70.6 | 69.9 | 70.0 | 71.1 |
| 4: 0 | 69.8 | 71.9 | 71.0 | 72.9 |
| 8: 0 | 71.3 | 73.5 | 74.0 | 70.3 |
| 12: 0 | 72.7 | 81.9 | 83.3 | 102.9 |
| 16: 0 | 74.1 | 92.6 | 90.8 | 158.1 |
| 20: 0 | 75.4 | 115.5 | 137.7 | 245.7 |
| 24: 0 | 80.9 | 235.4 | 258.0 | 357.7 |
| 28: 0 | 85.4 | 421.1 | 410.3 | 457.8 |
| 32: 0 | 92.7 | 547.4 | 483.2 | 516.3 |
| 36: 0 | 100.3 | 606.4 | 508.9 | 559.2 |
| 40: 0 | 109.9 | 644.4 | 530.0 | 595.2 |
| 44: 0 | 120.3 | 677.6 | 548.5 | 624.8 |
| 48: 0 | 131.4 | 711.3 | 564.2 | 649.7 |
| 52: 0 | 142.6 | 764.8 | 580.6 | 672.9 |
| 56: 0 | 154.1 | 866.7 | 599.9 | 697.0 |
| 60: 0 | 165.5 | 920.3 | 620.2 | 717.2 |

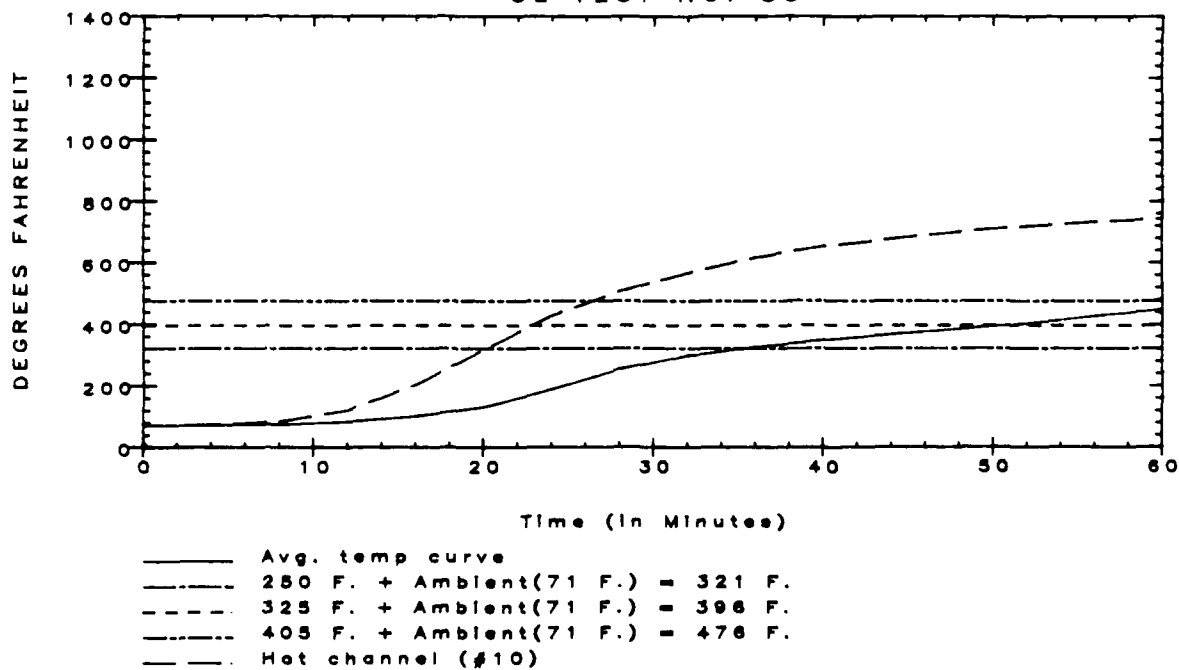
FILE USNC142
 ILL. 77A

U.S. COAST GUARD
 UL Test No. 33 - D22/A60U
 86NK8673/USNC142
 6-25-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 |
|------------|-------|-------|-------|
| TIME | | | |
| 0: 0 | 71.1 | 71.2 | 70.6 |
| 4: 0 | 72.8 | 73.4 | 70.8 |
| 8: 0 | 75.2 | 85.1 | 71.2 |
| 12: 0 | 83.9 | 121.2 | 73.8 |
| 16: 0 | 89.0 | 204.4 | 74.2 |
| 20: 0 | 118.7 | 316.8 | 75.1 |
| 24: 0 | 218.9 | 428.8 | 76.0 |
| 28: 0 | 351.1 | 507.6 | 81.6 |
| 32: 0 | 423.8 | 566.7 | 85.2 |
| 36: 0 | 456.7 | 617.7 | 91.2 |
| 40: 0 | 476.9 | 652.8 | 96.9 |
| 44: 0 | 494.4 | 678.1 | 105.8 |
| 48: 0 | 509.8 | 701.1 | 113.7 |
| 52: 0 | 524.6 | 719.2 | 122.8 |
| 56: 0 | 538.5 | 733.6 | 131.9 |
| 60: 0 | 553.2 | 745.0 | 141.2 |

SAMPLE D22/A60U
 UL TEST NO. 33



T E S T R E C O R D D22/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D22/A0 and as shown in ILL. 78.

The fire and hose stream tests were conducted on June 12, 1986 and identified by UL as Test No. 13.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|--|
| 1.5 | The cable ignited on the exposed side. |
| 4 | The RTV sealant on the exposed side is heavily charred. |
| 7 | The steel plate was black in color and bowing upward. |
| 10 | Smoke issued from the end of the cable. |
| 15 | The cable was supported with wire by UL's technical staff by request of the USCG. |
| 18 | Smoke issued from the interface of the cable and brass terminal tube. |
| 21 | The cable jacket turned whitish in color near the brass terminal tube. |
| 40 | The cable was again supported with wire by UL technical staff. The cable jacket was dripping down onto the steel plate and igniting. |
| 42 | The cable was issuing smoke and was heavily charred. |
| 59 | The cable jacket ignited. |
| 60 | Test terminated. |

- * A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 79.

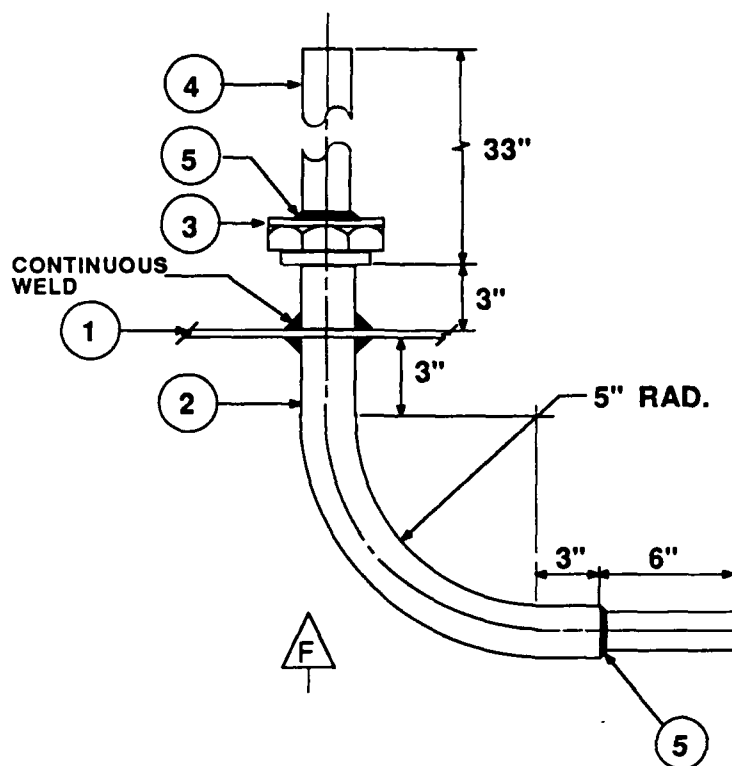
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 80 through 80B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D22/AO
UL TEST NO. 13



- ① STEEL PLATE, 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIAMETER, SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE V-200 FP
WITH PILOT HOLE DRILLED TO SUIT ELECTRICAL CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL CABLE
APPROX. 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT

TEST SAMPLE NO. D-22A
ELECTRICAL CABLE
WITH STEEL SPIGOT AND
BRASS TERMINAL TUBE
(R&DC GRAPHICS 36)

USNC 142
ILL. 78

SAMPLE D22/A0
TEST DATE JUNE 12, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On brass terminal tube (4 in. above steel plate). |
| 2 | On interface of brass terminal tube and cable (5-3/4 in. above steel plate). |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, 18 in. above steel plate. |
| 5 | On penetrant, 24 in. above steel plate. |
| 6 | On steel plate, 3 in. from penetrant. |
| 7 | On steel plate, 6 in. from penetrant. |
| 8 | On steel plate, 6 in. from penetrant. |
| 9 | On steel plate, 12 in. from penetrant. |
| 10 | On steel plate, 12 in. from penetrant. |
| 11 | On top of cable, on copper conductor. |

USNC142
ILL. 79

U.S. COAST GUARD
 UL Test No. 13 - D22/A0
 86NK8673/USNC142
 6-12-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 79.6 | 78.5 | 78.2 | 78.2 |
| 4: 0 | 107.6 | 81.7 | 81.9 | 79.8 |
| 8: 0 | 204.1 | 96.4 | 93.6 | 88.6 |
| 12: 0 | 307.1 | 152.6 | 128.1 | 112.7 |
| 16: 0 | 404.0 | 237.5 | 186.8 | 164.7 |
| 20: 0 | 481.8 | 288.9 | 246.9 | 221.7 |
| 24: 0 | 543.5 | 349.3 | 267.2 | 243.2 |
| 28: 0 | 595.0 | 413.3 | 300.0 | 256.4 |
| 32: 0 | 638.3 | 510.9 | 355.1 | 328.2 |
| 36: 0 | 683.7 | 582.5 | 420.1 | 407.8 |
| 40: 0 | 723.4 | 643.3 | 472.8 | 434.9 |
| 44: 0 | 747.1 | 713.2 | 511.3 | 466.6 |
| 48: 0 | 768.2 | 740.8 | 566.7 | 493.0 |
| 52: 0 | 787.4 | 769.4 | 708.6 | 524.9 |
| 56: 0 | 803.9 | 794.4 | 719.0 | 554.7 |
| 60: 0 | 823.2 | 817.6 | 726.4 | 601.0 |

FILE USNC142
 ILL. 80

U.S. COAST GUARD
 UL Test No. 13 - D22/A0
 86NK8673/USNC142
 6-12-86

| | Temperature Degrees F | | | |
|------------|-----------------------|--------|--------|--------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 79.8 | 82.0 | 83.2 | 84.3 |
| 4: 0 | 92.2 | 493.8 | 504.0 | 463.0 |
| 8: 0 | 85.0 | 921.5 | 958.9 | 853.8 |
| 12: 0 | 103.2 | 1129.3 | 1132.7 | 1093.1 |
| 16: 0 | 143.1 | 1190.2 | 1209.7 | 1133.7 |
| 20: 0 | 176.1 | 1244.5 | 1245.4 | 1206.0 |
| 24: 0 | 203.9 | 1280.1 | 1283.8 | 1241.9 |
| 28: 0 | 219.0 | 1313.7 | 1319.6 | 1280.2 |
| 32: 0 | 276.2 | 1353.1 | 1362.4 | 1323.0 |
| 36: 0 | 339.8 | 1395.6 | 1400.9 | 1359.9 |
| 40: 0 | 340.9 | 1427.1 | 1433.2 | 1396.1 |
| 44: 0 | 340.5 | 1454.3 | 1458.9 | 1419.7 |
| 48: 0 | 346.9 | 1481.1 | 1483.5 | 1444.7 |
| 52: 0 | 360.2 | 1506.7 | 1508.1 | 1467.1 |
| 56: 0 | 374.7 | 1525.0 | 1525.9 | 1488.0 |
| 60: 0 | 387.9 | 1537.4 | 1537.3 | 1502.6 |

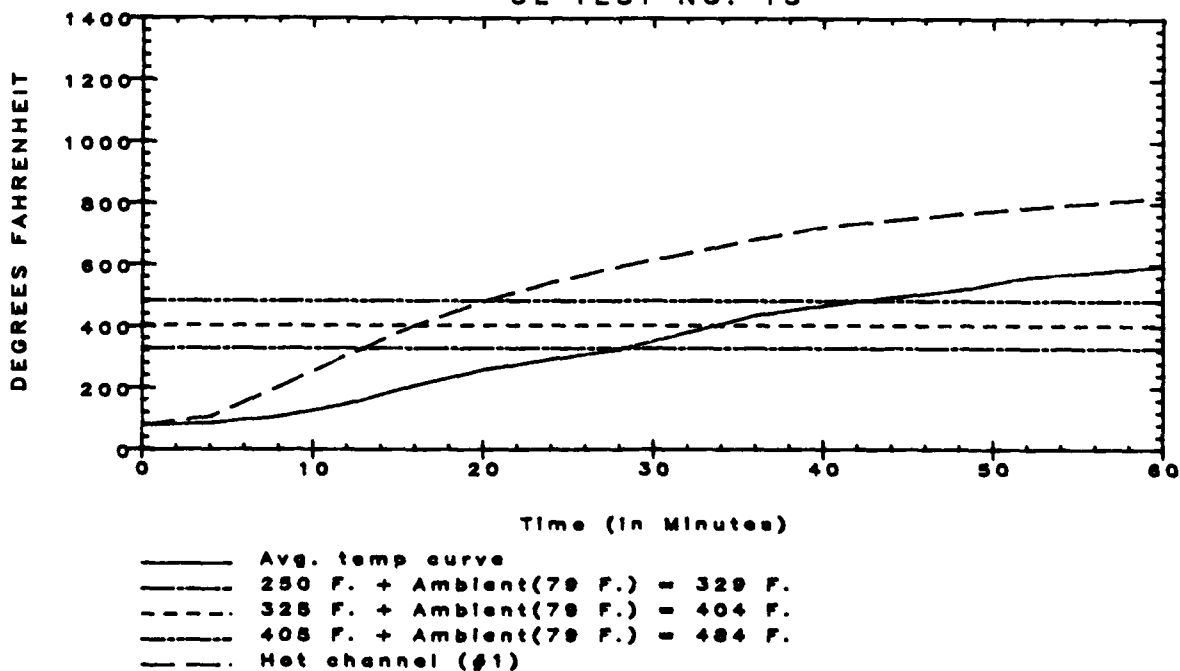
FILE USNC142
 ILL. 80A

U.S. COAST GUARD
 UL Test No. 13 - D22/A0
 86NK8673/USNC142
 6-12-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 |
|------------|--------|--------|-------|
| TIME | | | |
| 0: 0 | 82.0 | 85.2 | 78.4 |
| 4: 0 | 506.0 | 413.7 | 79.2 |
| 8: 0 | 945.7 | 769.8 | 82.8 |
| 12: 0 | 1156.8 | 1006.3 | 95.3 |
| 16: 0 | 1220.6 | 1083.8 | 119.8 |
| 20: 0 | 1269.3 | 1144.2 | 144.5 |
| 24: 0 | 1296.4 | 1190.9 | 158.2 |
| 28: 0 | 1326.9 | 1234.7 | 172.4 |
| 32: 0 | 1363.6 | 1285.2 | 176.9 |
| 36: 0 | 1399.2 | 1324.3 | 191.0 |
| 40: 0 | 1424.4 | 1358.2 | 198.0 |
| 44: 0 | 1449.3 | 1380.5 | 194.2 |
| 48: 0 | 1471.6 | 1403.8 | 207.2 |
| 52: 0 | 1493.9 | 1425.0 | 214.0 |
| 56: 0 | 1511.1 | 1444.8 | 225.7 |
| 60: 0 | 1516.3 | 1459.7 | 231.4 |

SAMPLE D22/A0
 UL TEST NO. 13



T E S T R E C O R D D23/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D23/A60E and as shown in ILL. 81.

The fire and hose stream tests were conducted on June 20, 1986 and identified by UL as Test No. 27.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 10 | Smoke issued from the interface of the steel pipe and cable. |
| 14 | Light smoke issued from the top of the cable. |
| 22 | The steel plate bowed upward. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 82.

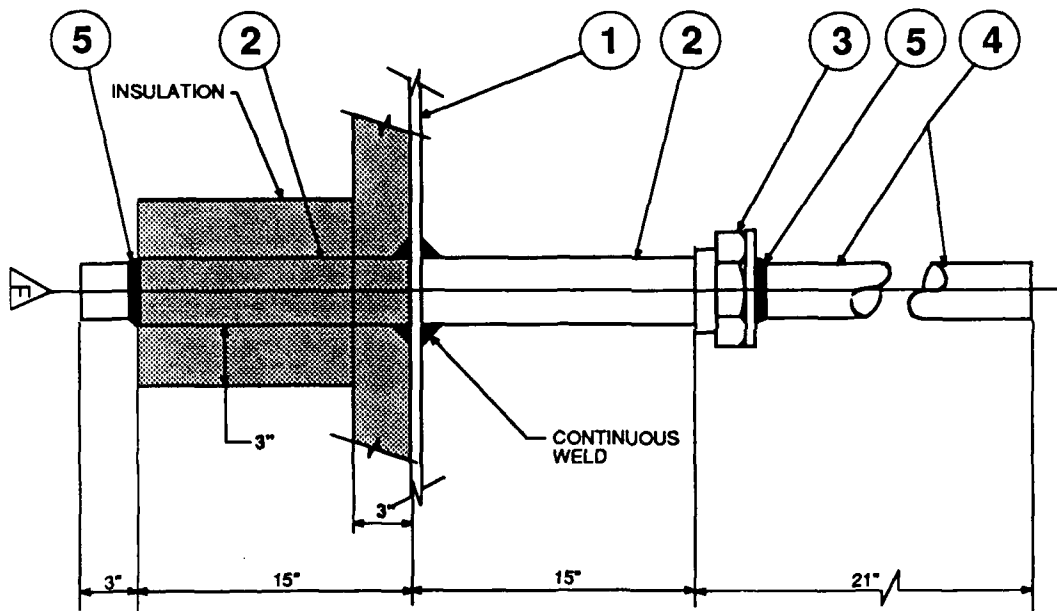
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 83 through 83B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIA. SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE
V-200 FP WITH PILOT HOLE DRILLED TO SUIT CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL
CABLE, APPROX 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-23A
ELECTRICAL CABLE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE

(R&DC GRAPHIC 20)

USNC 142
ILL. 81

SAMPLE D23/A60E
TEST DATE JUNE 20, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at interface of brass terminal tube and cable. |
| 5 | On brass terminal tube. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate over insulation, 3 in. from penetrant. |
| 8 | On steel plate over insulation, 6 in. from penetrant. |
| 9 | On steel plate over insulation seam, 6 in. from penetrant. |
| 10 | On steel plate over insulation, 12 in. from penetrant. |
| 11 | On steel plate over insulation seam, 12 in. from penetrant. |
| 12 | On top of cable, on copper conductor. |

USNC142
ILL. 82

U.S. COAST GUARD
 UL Test No. 27 - D23/A60E
 86NK8673/USNC142
 6-20-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NDS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 67.0 | 67.8 | 67.9 | 67.8 |
| 4: 0 | 69.1 | 68.4 | 68.5 | 67.0 |
| 8: 0 | 75.1 | 70.5 | 70.5 | 68.2 |
| 12: 0 | 91.6 | 79.8 | 72.5 | 70.9 |
| 16: 0 | 113.0 | 93.9 | 77.8 | 72.0 |
| 20: 0 | 133.4 | 109.4 | 83.7 | 74.9 |
| 24: 0 | 155.0 | 126.4 | 91.3 | 82.2 |
| 28: 0 | 171.4 | 140.1 | 98.3 | 85.0 |
| 32: 0 | 183.8 | 149.9 | 102.5 | 90.9 |
| 36: 0 | 205.4 | 159.4 | 107.7 | 95.4 |
| 40: 0 | 205.4 | 170.3 | 114.3 | 102.5 |
| 48: 0 | 227.1 | 191.6 | 134.0 | 122.4 |
| 52: 0 | 231.5 | 207.0 | 149.8 | 133.7 |
| 56: 0 | 231.0 | 217.3 | 176.0 | 146.8 |
| 60: 0 | 234.1 | 221.3 | 189.2 | 166.0 |

FILE USNC142
 ILL. 83

U.S. COAST GUARD
 UL Test No. 27 - D23/A60E
 86NK8673/USNC142
 6-20-86

| Temperature Degrees F | | | | |
|-----------------------|-------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 67.8 | 66.6 | 68.5 | 68.5 |
| 4: 0 | 69.3 | 67.2 | 70.1 | 69.4 |
| 8: 0 | 68.5 | 68.7 | 77.8 | 73.7 |
| 12: 0 | 70.4 | 69.7 | 92.8 | 83.3 |
| 16: 0 | 75.1 | 70.1 | 110.2 | 94.8 |
| 20: 0 | 76.5 | 72.1 | 129.2 | 110.0 |
| 24: 0 | 80.6 | 79.1 | 154.1 | 132.6 |
| 28: 0 | 84.4 | 79.6 | 175.2 | 151.6 |
| 32: 0 | 87.7 | 81.0 | 198.2 | 171.9 |
| 36: 0 | 90.1 | 83.6 | 220.2 | 193.5 |
| 40: 0 | 94.6 | 87.9 | 240.4 | 214.9 |
| 48: 0 | 108.1 | 98.0 | 276.4 | 252.3 |
| 52: 0 | 115.9 | 104.7 | 291.4 | 268.3 |
| 56: 0 | 129.7 | 112.3 | 303.5 | 282.0 |
| 60: 0 | 148.8 | 121.4 | 313.9 | 292.8 |

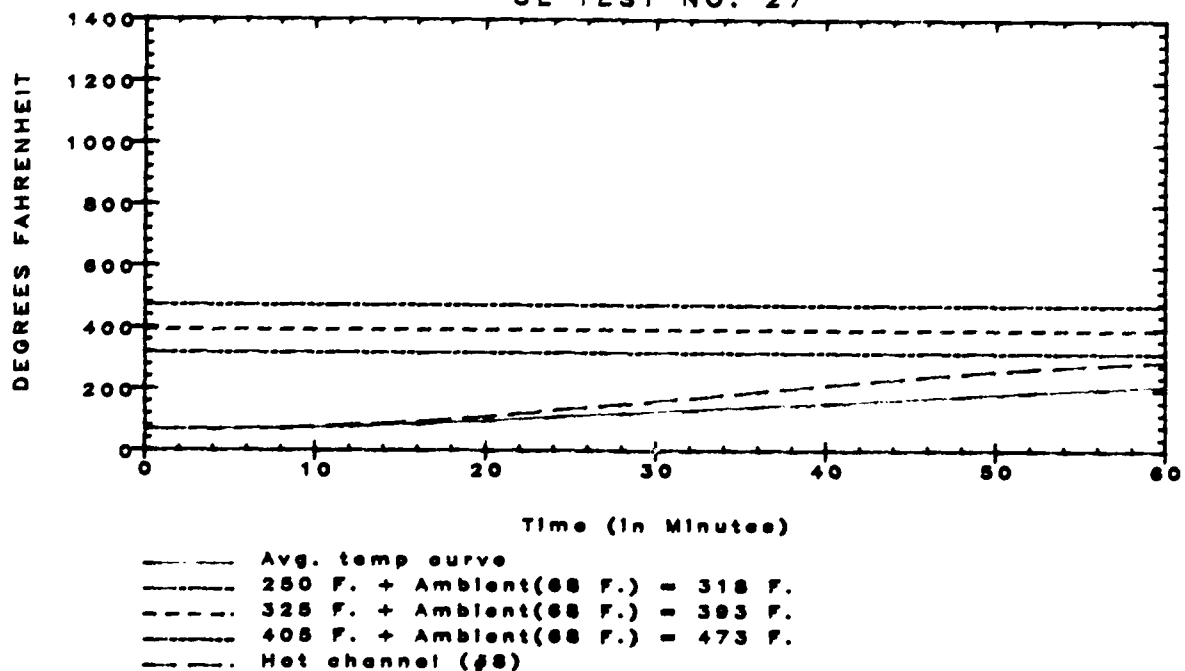
FILE USNC142
 ILL. 83A

U.S. COAST GUARD
 UL Test No. 27 - D23/A60E
 86NK8673/USNC142
 6-20-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|------|
| TIME | | | | |
| 0: 0 | 68.6 | 68.6 | 68.6 | 67.9 |
| 4: 0 | 69.1 | 71.3 | 70.5 | 68.5 |
| 8: 0 | 72.2 | 74.8 | 73.6 | 68.9 |
| 12: 0 | 79.1 | 80.5 | 78.0 | 69.8 |
| 16: 0 | 88.9 | 87.6 | 86.4 | 74.5 |
| 20: 0 | 100.4 | 96.0 | 95.7 | 76.0 |
| 24: 0 | 120.0 | 111.8 | 111.4 | 77.2 |
| 28: 0 | 137.5 | 126.8 | 126.1 | 77.3 |
| 32: 0 | 156.7 | 144.4 | 143.2 | 77.1 |
| 36: 0 | 176.4 | 159.7 | 158.4 | 78.3 |
| 40: 0 | 197.7 | 173.7 | 172.9 | 80.0 |
| 48: 0 | 233.2 | 208.6 | 206.0 | 84.3 |
| 52: 0 | 248.9 | 225.5 | 220.0 | 87.4 |
| 56: 0 | 262.0 | 241.0 | 233.2 | 91.9 |
| 60: 0 | 272.9 | 254.5 | 245.2 | 95.7 |

SAMPLE D23/A60E
 UL TEST NO. 27



T E S T R E C O R D D23/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D23/A60U and as shown in ILL. 84.

The fire and hose stream tests were conducted on June 24, 1986 and identified by UL as Test No. 31.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|--|
| 6 | Smoke issued from the top of the cable. The steel plate and the insulation bowed upward. |
| 9 | Smoke issued from the RTV sealant at the interface of the brass terminal tube and cable. |
| 16 | All smoke intensity decreased. |
| 21 | All the smoke that was issuing stopped. |
| 40 | The steel plate along with the insulation receded. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 85.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 86 through 86B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

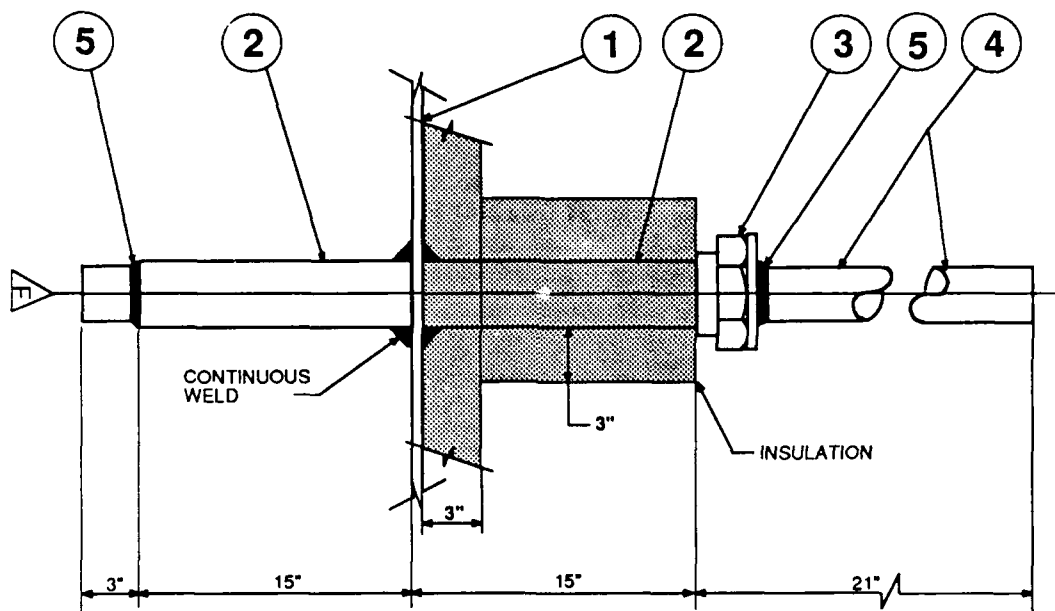
* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

File USNC142

Issued: 8-15-86

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIA. SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE
V-200 FP WITH PILOT HOLE DRILLED TO SUIT CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL
CABLE, APPROX 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-23A
ELECTRICAL CABLE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE
(R&DC GRAPHIC 21)

USNC 142
ILL. 84

SAMPLE D23/A60U
TEST DATE JUNE 24, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at interface of brass terminal tube and cable. |
| 5 | On brass terminal tube. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | At interface of penetrant insulation and steel plate insulation. |
| 8 | On steel plate insulation, 6 in. from penetrant. |
| 9 | On steel plate insulation seam, 6 in. from penetrant. |
| 10 | On steel plate insulation, 12 in. from penetrant. |
| 11 | On steel plate insulation seam, 12 in. from penetrant. |
| 12 | On top of cable, on copper conductor. |

USNC142
ILL. 85

U.S. COAST GUARD
 UL Test No. 31 - D23/A60U
 86NK8673/USNC142
 6-24-86

Temperature Degrees F

| CHAN(NOS.) | 1 | 2 | 3 | 4 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 66.3 | 66.1 | 66.1 | 64.9 |
| 4: 0 | 66.1 | 65.0 | 65.7 | 64.9 |
| 8: 0 | 67.3 | 67.7 | 67.2 | 65.3 |
| 12: 0 | 69.8 | 70.2 | 68.7 | 68.4 |
| 16: 0 | 74.3 | 72.8 | 70.7 | 74.8 |
| 20: 0 | 78.5 | 76.1 | 72.0 | 87.1 |
| 24: 0 | 89.3 | 84.2 | 76.5 | 104.0 |
| 28: 0 | 128.2 | 97.5 | 83.6 | 125.6 |
| 32: 0 | 182.7 | 114.7 | 89.9 | 158.6 |
| 36: 0 | 225.1 | 120.6 | 94.0 | 165.6 |
| 40: 0 | 255.9 | 129.0 | 98.8 | 182.3 |
| 44: 0 | 278.6 | 137.5 | 103.6 | 196.0 |
| 48: 0 | 298.3 | 148.9 | 107.6 | 209.8 |
| 52: 0 | 308.6 | 155.9 | 111.3 | 218.2 |
| 56: 0 | 320.3 | 165.1 | 114.7 | 231.6 |
| 60: 0 | 331.4 | 174.0 | 118.9 | 247.9 |

FILE USNC142
 ILL. 86

U.S. COAST GUARD
 UL Test No. 31 - D23/A60U
 86NK8673/USNC142
 6-24-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 65.0 | 65.4 | 67.1 | 66.2 |
| 4: 0 | 36.9 | 63.8 | 66.4 | 66.0 |
| 8: 0 | 65.2 | 64.1 | 69.3 | 70.2 |
| 12: 0 | 68.1 | 67.5 | 83.5 | 80.7 |
| 16: 0 | 73.8 | 70.8 | 97.3 | 93.6 |
| 20: 0 | 79.5 | 73.1 | 184.3 | 177.7 |
| 24: 0 | 91.0 | 82.5 | 376.0 | 355.3 |
| 28: 0 | 108.1 | 96.2 | 541.5 | 455.2 |
| 32: 0 | 127.9 | 111.7 | 609.9 | 490.5 |
| 36: 0 | 151.3 | 126.6 | 642.9 | 509.4 |
| 40: 0 | 163.5 | 139.9 | 663.4 | 524.1 |
| 44: 0 | 186.5 | 165.3 | 700.8 | 554.5 |
| 48: 0 | 186.8 | 165.7 | 701.3 | 554.9 |
| 52: 0 | 196.0 | 175.6 | 713.6 | 565.0 |
| 56: 0 | 206.6 | 184.6 | 726.8 | 577.9 |
| 60: 0 | 217.6 | 192.3 | 738.5 | 587.7 |

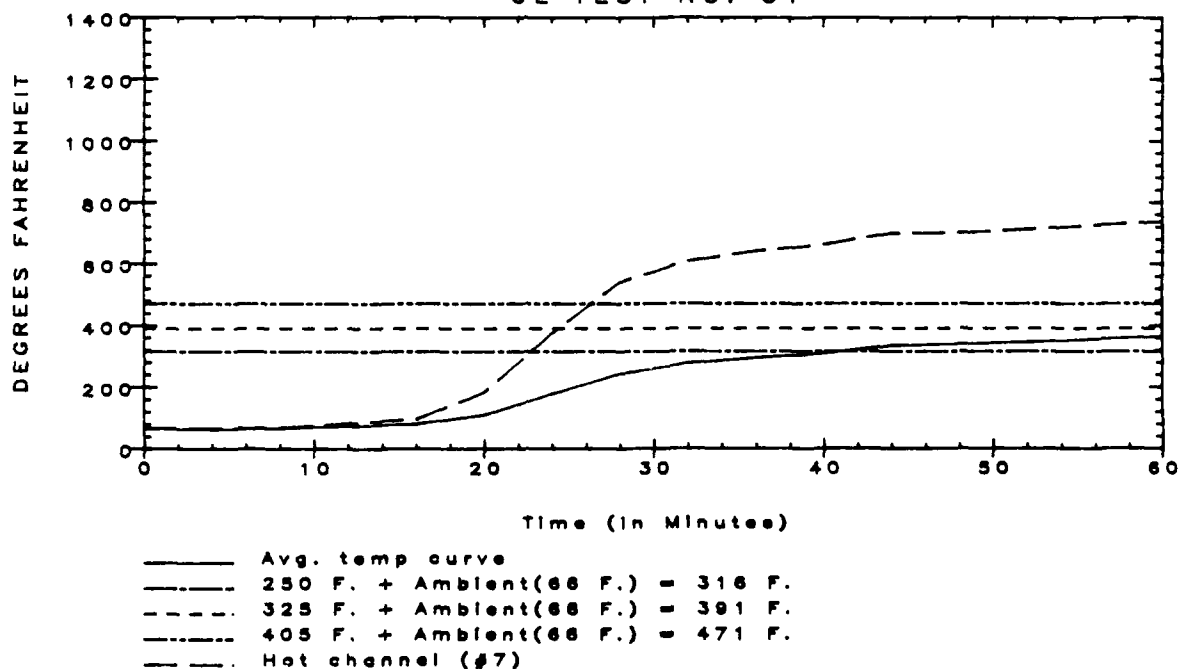
FILE USNC142
 ILL. 86A

U.S. COAST GUARD
 UL Test No. 31 - D23/A60U
 86NK8673/USNC142
 6-24-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 66.8 | 66.3 | 66.3 | 65.1 |
| 4: 0 | 65.4 | 66.9 | 65.8 | 63.8 |
| 8: 0 | 68.6 | 75.7 | 71.5 | 64.0 |
| 12: 0 | 78.9 | 89.5 | 83.8 | 68.0 |
| 16: 0 | 87.0 | 106.3 | 95.7 | 69.5 |
| 20: 0 | 149.2 | 155.2 | 136.0 | 70.6 |
| 24: 0 | 308.3 | 264.6 | 244.3 | 71.9 |
| 28: 0 | 452.4 | 369.3 | 389.4 | 76.4 |
| 32: 0 | 502.2 | 409.0 | 456.5 | 83.2 |
| 36: 0 | 520.8 | 422.2 | 481.7 | 92.0 |
| 40: 0 | 532.8 | 426.6 | 496.4 | 102.9 |
| 44: 0 | 559.3 | 439.8 | 521.4 | 182.0 |
| 48: 0 | 559.7 | 440.1 | 521.9 | 182.5 |
| 52: 0 | 568.5 | 442.4 | 534.2 | 165.9 |
| 56: 0 | 579.6 | 451.7 | 542.5 | 168.1 |
| 60: 0 | 589.4 | 457.7 | 549.9 | 184.7 |

SAMPLE D23/A60U
 UL TEST NO. 31



T E S T R E C O R D D23/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D23/A0 and as shown in ILL. 87.

The fire and hose stream tests were conducted on June 19, 1986 and identified by UL as Test No. 25.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations*</u> |
|-----------------------|--|
| 4 | Smoke issued from the interface of the cable and brass terminal tube for approximately 30 seconds. |
| 9 | Smoke issued from the top of the cable. |
| 13 | The smoke intensity decreased in all areas. |
| 15 | The steel plate was bowing upward and turning blackish in color. |
| 30 | The steel plate was starting to glow red in color. |
| 40 | The cable jacket began to melt by the brass terminal tube. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 88.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 89 through 89B.

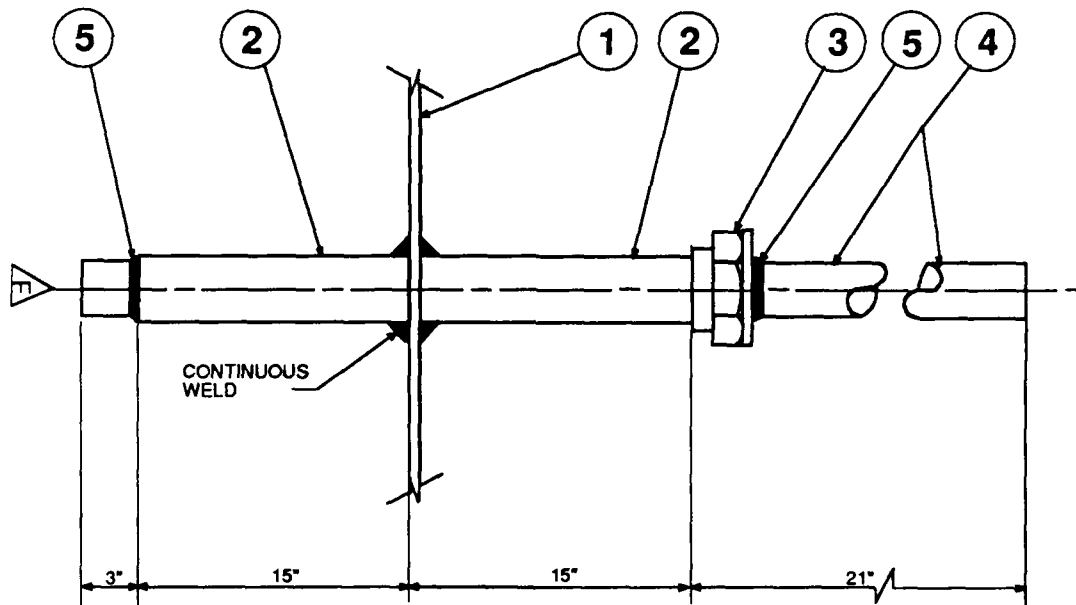
* A review of the above photographic documentation shows that smoke, recorded in the above observations, did not pass through the penetrant.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIA. SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE
V-200 FP WITH PILOT HOLE DRILLED TO SUIT CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL
CABLE, APPROX 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-23A
ELECTRICAL CABLE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE
(RADC GRAPHIC 22)

USNC 142
ILL. 87

SAMPLE D23/A0
TEST DATE JUNE 19, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at interface of brass terminal tube and cable. |
| 5 | On brass terminal tube. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate, 3 in. from penetrant. |
| 8 | On steel plate, 6 in. from penetrant. |
| 9 | On steel plate, 6 in. from penetrant. |
| 10 | On steel plate, 12 in. from penetrant. |
| 11 | On steel plate, 12 in. from penetrant. |
| 12 | On top of cable, on copper conductor. |

USNC142
ILL. 88

U.S. COAST GUARD
UL Test No. 25 - D23/A0
86NK8673/USNC142
6-19-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NDS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 80.2 | 79.4 | 78.8 | 78.5 |
| 4: 0 | 80.3 | 79.4 | 78.8 | 78.4 |
| 8: 0 | 291.4 | 190.0 | 129.2 | 88.6 |
| 12: 0 | 442.4 | 305.6 | 201.2 | 100.5 |
| 16: 0 | 528.7 | 388.6 | 263.3 | 119.5 |
| 20: 0 | 587.6 | 450.6 | 313.4 | 146.7 |
| 24: 0 | 616.5 | 489.0 | 348.5 | 178.3 |
| 28: 0 | 647.5 | 523.8 | 378.6 | 213.9 |
| 32: 0 | 671.2 | 550.5 | 404.9 | 234.6 |
| 36: 0 | 704.5 | 581.3 | 432.3 | 252.3 |
| 40: 0 | 710.2 | 599.1 | 455.3 | 273.8 |
| 44: 0 | 725.3 | 620.5 | 474.8 | 293.2 |
| 48: 0 | 742.9 | 643.5 | 496.0 | 316.0 |
| 52: 0 | 754.2 | 657.4 | 510.0 | 330.9 |
| 56: 0 | 772.7 | 673.6 | 527.3 | 348.0 |
| 60: 0 | 786.4 | 686.8 | 544.8 | 369.2 |

FILE USNC142
ILL. 89

U.S. COAST GUARD
 UL Test No. 25 - D23/A0
 86NK8673/USNC142
 6-19-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|--------|--------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 78.6 | 78.5 | 83.8 | 83.0 |
| 4: 0 | 78.6 | 77.4 | 83.8 | 83.9 |
| 8: 0 | 103.8 | 89.3 | 1042.8 | 1055.6 |
| 12: 0 | 141.8 | 106.4 | 1224.8 | 1224.9 |
| 16: 0 | 182.7 | 121.0 | 1297.3 | 1255.3 |
| 20: 0 | 222.1 | 135.0 | 1334.5 | 1329.7 |
| 24: 0 | 255.2 | 152.7 | 1356.1 | 1351.9 |
| 28: 0 | 284.9 | 174.8 | 1382.5 | 1377.9 |
| 32: 0 | 312.3 | 209.7 | 1413.8 | 1410.1 |
| 36: 0 | 332.7 | 225.0 | 1441.8 | 1441.7 |
| 40: 0 | 352.7 | 231.7 | 1469.9 | 1471.0 |
| 44: 0 | 372.2 | 243.2 | 1494.3 | 1495.2 |
| 48: 0 | 391.7 | 257.3 | 1518.2 | 1514.2 |
| 52: 0 | 407.1 | 271.6 | 1533.0 | 1525.6 |
| 56: 0 | 424.1 | 288.2 | 1549.4 | 1538.4 |
| 60: 0 | 440.5 | 307.7 | 1562.8 | 1548.6 |

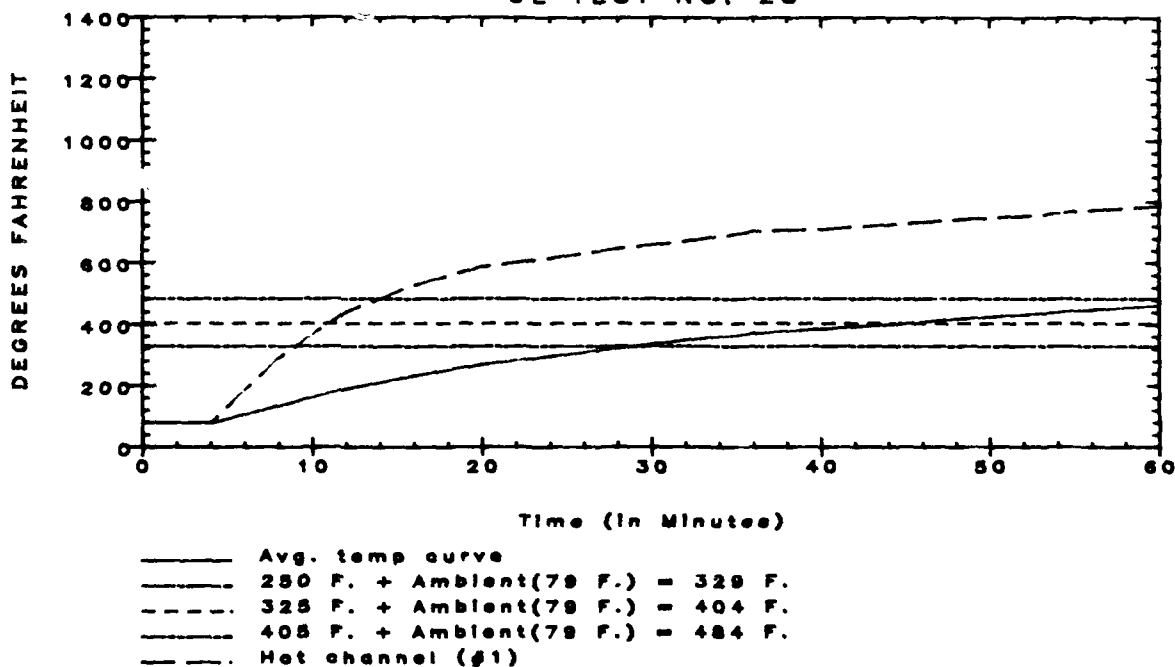
FILE USNC142
 ILL. 89A

U.S. COAST GUARD
UL Test No. 25 - D23/A0
86NK8673/USNC142
6-19-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|--------|--------|--------|-------|
| TIME | | | | |
| 0: 0 | 84.5 | 83.6 | 84.4 | 78.5 |
| 4: 0 | 84.5 | 83.6 | 84.4 | 78.5 |
| 8: 0 | 1107.8 | 904.7 | 1022.5 | 94.4 |
| 12: 0 | 1255.9 | 1120.8 | 1202.6 | 110.7 |
| 16: 0 | 1315.1 | 1205.2 | 1272.1 | 123.7 |
| 20: 0 | 1347.8 | 1256.3 | 1302.7 | 134.5 |
| 24: 0 | 1373.7 | 1285.7 | 1321.8 | 149.0 |
| 28: 0 | 1401.7 | 1309.3 | 1354.4 | 160.8 |
| 32: 0 | 1431.4 | 1341.4 | 1384.6 | 176.4 |
| 36: 0 | 1456.6 | 1375.2 | 1409.5 | 190.9 |
| 40: 0 | 1477.6 | 1387.3 | 1435.7 | 200.6 |
| 44: 0 | 1499.0 | 1405.3 | 1453.4 | 197.5 |
| 48: 0 | 1515.6 | 1407.8 | 1468.0 | 214.0 |
| 52: 0 | 1537.9 | 1402.2 | 1485.0 | 224.4 |
| 56: 0 | 1557.2 | 1401.4 | 1506.1 | 238.1 |
| 60: 0 | 1577.5 | 1412.9 | 1528.4 | 234.9 |

SAMPLE D23/A0
UL TEST NO. 25



T E S T R E C O R D D24/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D24/A60E and as shown in ILL. 90.

The fire and hose stream tests were conducted on June 10, 1986 and identified by UL as Test No. 10.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 15 | Light smoke issued from the periphery. |
| 25 | Smoke issued from the interface of the steel pipe and cable. |
| 44 | Smoke issued from the top of the cable. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 91.

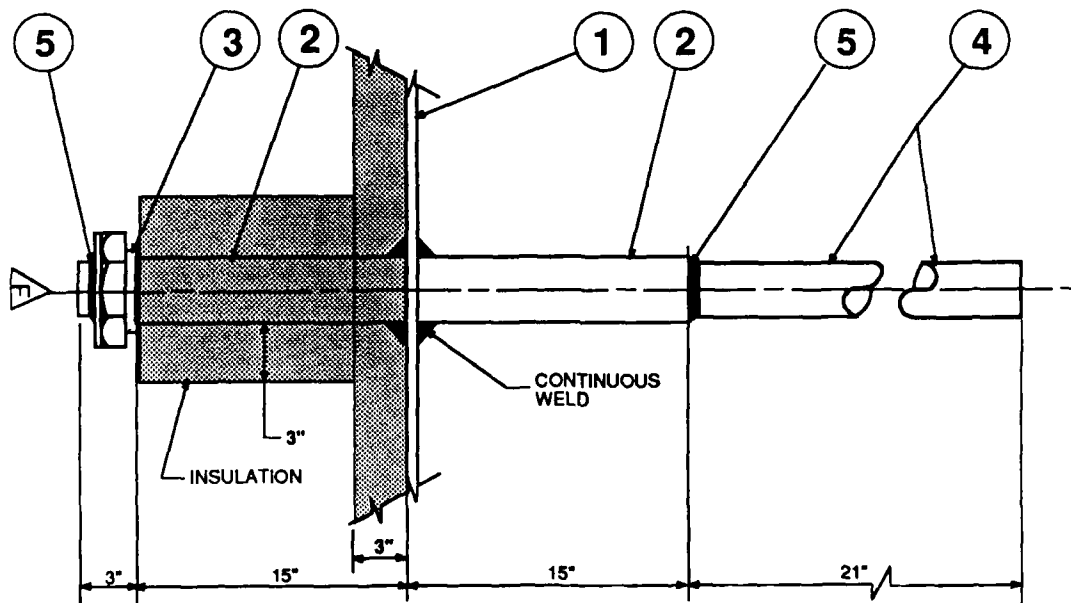
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 92 through 92B. .

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIA. SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE V-200 FP
WITH PILOT HOLE DRILLED TO SUIT ELECTRICAL CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL
CABLE, APPROX 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-24A
ELECTRICAL CABLE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE
(R&DC GRAPHIC 24)

USNC 142
ILL. 90

SAMPLE D24/A60E
TEST DATE JUNE 10, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On cable, 1 in. above steel pipe. |
| 5 | On penetrant, at interface of steel pipe and cable. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate over insulation, 3 in. from penetrant. |
| 8 | On steel plate over insulation, 6 in. from penetrant. |
| 9 | On steel plate over insulation seam, 6 in. from penetrant. |
| 10 | On steel plate over insulation, 12 in. from penetrant. |
| 11 | On steel plate over insulation seam, 12 in. from penetrant. |
| 12 | On top of cable, on copper conductor. |

USNC142
ILL. 91

U.S. COAST GUARD
 UL Test No. 10 - D24/A60E
 86NK8673/USNC142
 6-10-86

Temperature Degrees F

| CHAN(NOS.) | 1 | 2 | 3 | 4 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 77.7 | 77.8 | 77.8 | 76.5 |
| 4: 0 | 77.9 | 77.0 | 76.8 | 76.7 |
| 8: 0 | 78.5 | 78.4 | 77.2 | 77.5 |
| 12: 0 | 79.5 | 79.2 | 77.6 | 77.5 |
| 16: 0 | 82.5 | 81.1 | 80.5 | 78.1 |
| 20: 0 | 86.4 | 84.3 | 81.3 | 79.6 |
| 24: 0 | 95.0 | 90.3 | 83.0 | 81.7 |
| 28: 0 | 110.0 | 101.2 | 88.1 | 86.3 |
| 32: 0 | 130.7 | 120.0 | 94.0 | 89.7 |
| 36: 0 | 150.0 | 137.9 | 103.1 | 91.4 |
| 40: 0 | 166.2 | 152.5 | 113.6 | 96.1 |
| 44: 0 | 181.8 | 162.1 | 118.0 | 100.5 |
| 48: 0 | 190.7 | 177.2 | 124.1 | 104.8 |
| 52: 0 | 197.9 | 187.2 | 130.9 | 111.4 |
| 56: 0 | 200.4 | 188.6 | 136.2 | 119.0 |
| 60: 0 | 200.0 | 184.1 | 141.3 | 127.0 |

FILE USNC142
 ILL. 92

U.S. COAST GUARD
 UL Test No. 10 - D24/A60E
 86NK8673/USNC142
 6-10-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 76.6 | 76.4 | 77.9 | 78.7 |
| 4: 0 | 77.0 | 76.6 | 78.0 | 79.5 |
| 8: 0 | 78.4 | 76.9 | 80.5 | 82.8 |
| 12: 0 | 77.7 | 77.1 | 84.6 | 87.7 |
| 16: 0 | 81.8 | 77.5 | 92.2 | 95.7 |
| 20: 0 | 84.5 | 77.9 | 105.0 | 110.6 |
| 24: 0 | 87.0 | 78.7 | 123.0 | 130.2 |
| 28: 0 | 88.2 | 79.6 | 143.4 | 149.1 |
| 32: 0 | 91.7 | 80.8 | 161.1 | 164.3 |
| 36: 0 | 95.9 | 82.3 | 179.7 | 182.4 |
| 40: 0 | 101.5 | 84.8 | 198.8 | 200.3 |
| 44: 0 | 106.4 | 88.0 | 215.3 | 216.5 |
| 48: 0 | 110.9 | 90.9 | 230.4 | 231.3 |
| 52: 0 | 117.1 | 94.5 | 243.9 | 244.2 |
| 56: 0 | 123.7 | 98.0 | 256.3 | 255.7 |
| 60: 0 | 130.7 | 102.3 | 269.0 | 266.4 |

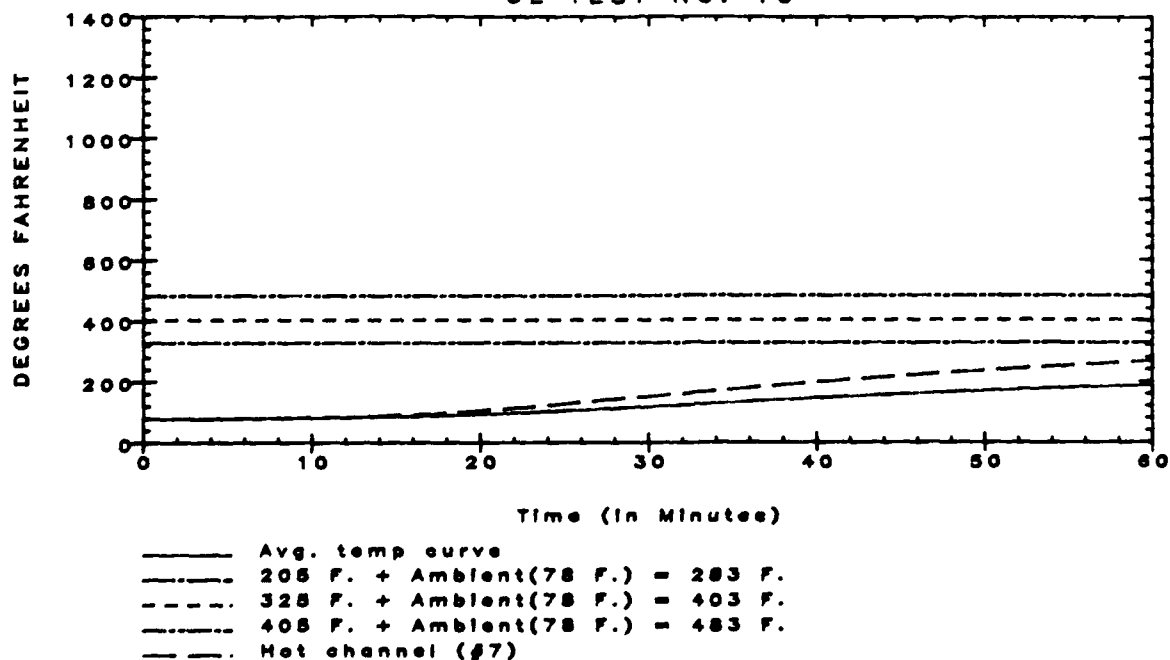
FILE USNC142
 ILL. 92A

U.S. COAST GUARD
 UL Test No. 10 - D24/A60E
 86NK8673/USNC142
 6-10-86

Temperature Degrees F

| CHAN(NDS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|------|
| TIME | | | | |
| 0: 0 | 78.8 | 78.7 | 79.2 | 77.5 |
| 4: 0 | 79.8 | 80.7 | 84.2 | 77.8 |
| 8: 0 | 80.7 | 84.6 | 88.9 | 77.0 |
| 12: 0 | 85.0 | 91.0 | 93.6 | 78.4 |
| 16: 0 | 92.4 | 96.4 | 100.6 | 78.8 |
| 20: 0 | 102.9 | 109.1 | 111.5 | 79.2 |
| 24: 0 | 119.2 | 125.1 | 126.5 | 80.1 |
| 28: 0 | 137.2 | 141.5 | 143.3 | 80.5 |
| 32: 0 | 153.8 | 155.9 | 159.0 | 81.4 |
| 36: 0 | 168.6 | 169.5 | 173.2 | 82.5 |
| 40: 0 | 185.8 | 184.5 | 187.0 | 84.4 |
| 44: 0 | 201.5 | 199.3 | 200.9 | 89.0 |
| 48: 0 | 215.5 | 212.7 | 214.3 | 91.9 |
| 52: 0 | 227.8 | 224.6 | 226.1 | 93.2 |
| 56: 0 | 239.1 | 235.1 | 237.4 | 95.3 |
| 60: 0 | 249.4 | 244.8 | 248.0 | 97.8 |

SAMPLE D24/A60E
 UL TEST NO. 10



T E S T R E C O R D D24/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D24/A60U and as shown in ILL. 93.

The fire and hose stream tests were conducted on June 13, 1986 and identified by UL as Test No. 16.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 2 | The cable was burning on the exposed side. |
| 9 | Smoke issued from the periphery, the top of the cable and from the top of the penetrant insulation. |
| 20 | Smoke intensity in all areas decreased. |
| 40 | Smoke intensity at top of penetrant insulation has increased. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 94.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 95 through 95B.

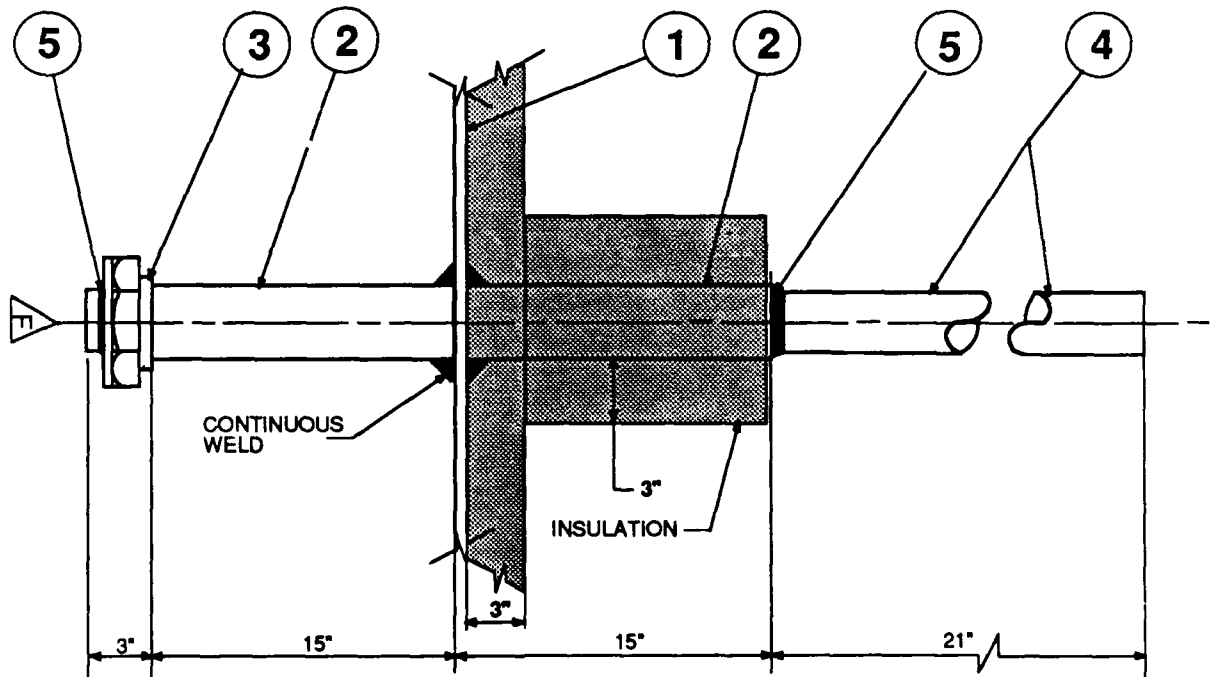
HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D24/A60U
UL TEST NO.16

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIA. SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE V-200 FP
WITH PILOT HOLE DRILLED TO SUIT ELECTRICAL CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL
CABLE, APPROX 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-24A
ELECTRICAL CABLE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE
(R&DC GRAPHIC 25)

USNC 142
ILL. 93

SAMPLE D24/A60U
TEST DATE JUNE 13, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On cable, 1 in. above steel pipe. |
| 5 | On penetrant at interface of cable and steel pipe. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | At interface of penetrant insulation and steel plate insulation. |
| 8 | On steel plate insulation, 6 in. from penetrant. |
| 9 | On steel plate insulation seam, 6 in. from penetrant. |
| 10 | On steel plate insulation, 12 in. from penetrant. |
| 11 | On steel plate insulation seam, 12 in. from penetrant. |
| 12 | On top of cable, on copper conductor. |

USNC142
ILL. 94

U.S. COAST GUARD
 UL Test No. 16 - D24/A60U
 86NK8673/USNC142
 6-13-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 72.4 | 72.9 | 71.5 | 70.3 |
| 4: 0 | 73.3 | 73.7 | 73.2 | 70.8 |
| 8: 0 | 74.6 | 75.4 | 74.8 | 72.3 |
| 12: 0 | 76.6 | 77.3 | 76.1 | 77.4 |
| 16: 0 | 78.4 | 79.3 | 77.4 | 85.1 |
| 20: 0 | 82.9 | 84.0 | 78.2 | 95.3 |
| 24: 0 | 97.8 | 96.8 | 81.2 | 109.1 |
| 28: 0 | 124.3 | 116.1 | 87.4 | 126.2 |
| 32: 0 | 159.5 | 134.9 | 93.6 | 143.6 |
| 36: 0 | 181.5 | 147.7 | 97.9 | 169.9 |
| 40: 0 | 202.9 | 158.1 | 102.9 | 185.3 |
| 44: 0 | 216.7 | 169.3 | 107.5 | 195.6 |
| 48: 0 | 225.4 | 176.8 | 111.2 | 203.7 |
| 52: 0 | 232.0 | 179.8 | 114.4 | 212.3 |
| 56: 0 | 243.5 | 189.4 | 117.9 | 221.5 |
| 60: 0 | 241.8 | 204.0 | 122.0 | 232.9 |

FILE USNC142
 ILL. 95

U.S. COAST GUARD
 UL Test No. 16 - D24/A60U
 86NK8673/USNC142
 6-13-86

Temperature Degrees F

| CHAN(NOS.) | 5 | 6 | 7 | 8 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 72.4 | 70.2 | 74.8 | 75.9 |
| 4: 0 | 71.8 | 70.5 | 75.5 | 76.4 |
| 8: 0 | 72.5 | 71.9 | 80.2 | 78.9 |
| 12: 0 | 93.5 | 74.3 | 86.1 | 84.2 |
| 16: 0 | 110.4 | 76.0 | 98.5 | 91.3 |
| 20: 0 | 125.3 | 80.4 | 147.7 | 128.7 |
| 24: 0 | 140.6 | 85.6 | 252.8 | 233.2 |
| 28: 0 | 157.2 | 94.4 | 365.5 | 362.1 |
| 32: 0 | 174.2 | 106.7 | 427.2 | 425.5 |
| 36: 0 | 193.6 | 120.6 | 448.6 | 454.6 |
| 40: 0 | 206.1 | 137.6 | 456.3 | 471.9 |
| 44: 0 | 217.5 | 154.0 | 458.3 | 487.1 |
| 48: 0 | 228.2 | 169.2 | 462.9 | 498.8 |
| 52: 0 | 240.0 | 182.3 | 449.1 | 509.4 |
| 56: 0 | 253.5 | 189.0 | 459.4 | 520.7 |
| 60: 0 | 269.6 | 194.2 | 451.3 | 531.7 |

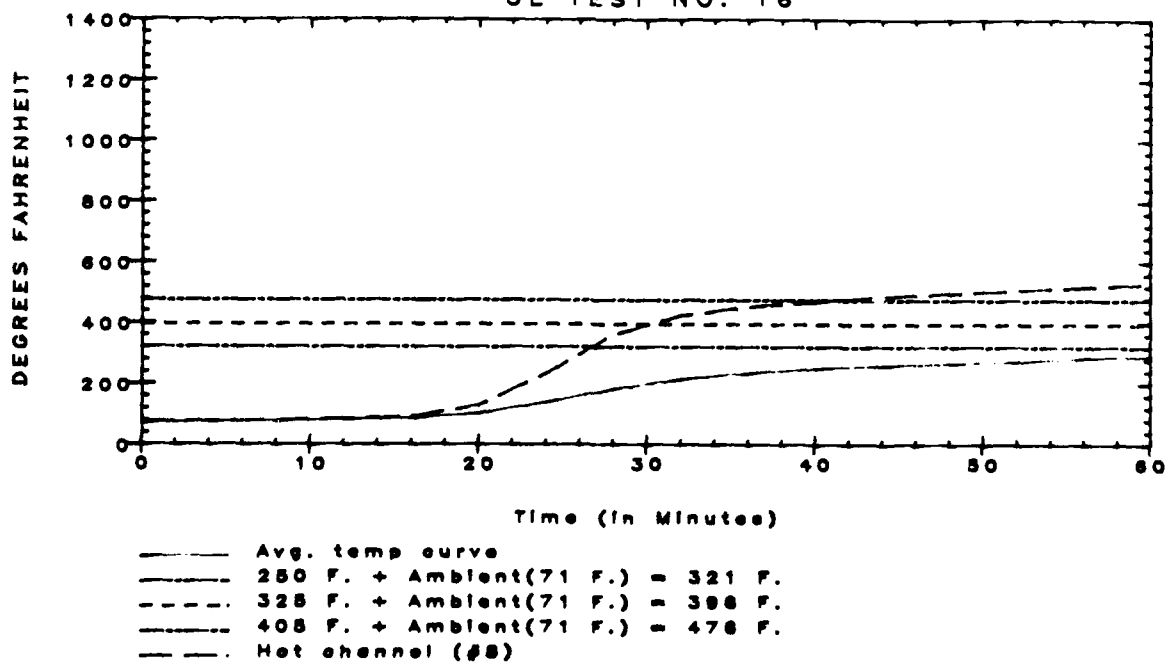
FILE USNC142
 ILL. 95A

U.S. COAST GUARD
 UL Test No. 16 - D24/A60U
 86NK8673/USNC142
 6-13-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 74.1 | 74.0 | 71.6 | 71.6 |
| 4: 0 | 75.4 | 76.6 | 77.4 | 76.5 |
| 8: 0 | 77.3 | 79.2 | 77.4 | 74.1 |
| 12: 0 | 81.0 | 83.8 | 80.8 | 86.9 |
| 16: 0 | 87.2 | 90.3 | 84.5 | 75.7 |
| 20: 0 | 109.5 | 119.9 | 93.9 | 77.4 |
| 24: 0 | 169.7 | 193.0 | 119.3 | 79.9 |
| 28: 0 | 241.6 | 258.6 | 161.1 | 81.1 |
| 32: 0 | 304.1 | 320.7 | 211.7 | 86.8 |
| 36: 0 | 317.8 | 339.1 | 257.4 | 93.3 |
| 40: 0 | 335.0 | 358.7 | 291.5 | 98.1 |
| 44: 0 | 335.3 | 368.6 | 312.3 | 105.3 |
| 48: 0 | 325.8 | 373.0 | 321.8 | 113.3 |
| 52: 0 | 330.0 | 385.3 | 329.9 | 123.0 |
| 56: 0 | 350.2 | 415.6 | 344.1 | 130.1 |
| 60: 0 | 346.3 | 421.8 | 345.2 | 136.3 |

SAMPLE D24/A60U
 UL TEST NO. 16



T E S T R E C O R D D24/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D24/A0 and as shown in ILL. 96.

The fire and hose stream tests were conducted on June 19, 1986 and identified by UL as Test No. 26.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|--|
| 5 | The steel plate turned black in color and was bowing downward. |
| 6 | The RTV sealant melted and dripped down on the steel pipe. Smoke issued from the interface of the cable and the steel pipe. |
| 7 | Smoke issued from the top of the cable. The melting RTV sealant on the steel pipe was issuing smoke. |
| 15 | The cable jacket at the interface of the steel pipe was softening. |
| 30 | The smoke intensity decreased. |
| 40 | The smoke intensity increased at the interface of the cable and the steel pipe. The cable jacket by the steel pipe was melting. The steel plate was glowing red. |
| 54 | The cable jacket was badly damaged at the interface of the steel pipe. |
| 60 | Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 97.

File USNC142

Issued: 8-15-86

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 98 through 98B.

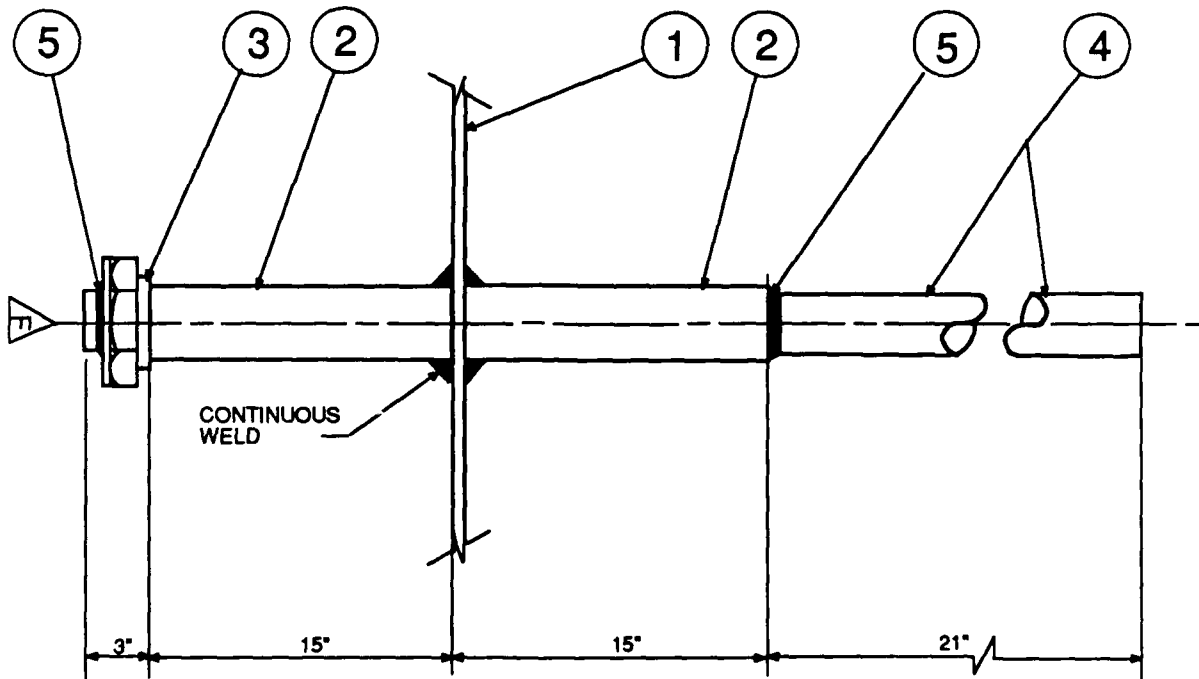
HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D24/AO
UL TEST NO. 26

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② SEAMLESS STEEL PIPE, 2" NOMINAL
DIA. SCHEDULE 40.
- ③ BRASS TERMINAL TUBE "KONDU" TYPE V-200 FP
WITH PILOT HOLE DRILLED TO SUIT ELECTRICAL CABLE.
- ④ C.C.G. APPROVED MARINE ELECTRICAL
CABLE, APPROX 2" O/DIA.
- ⑤ FIRE RESISTANT SEALANT



TEST SAMPLE NO. D-24A
ELECTRICAL CABLE WITH
STEEL SPIGOT AND
BRASS TERMINAL TUBE
(R&DC GRAPHIC 23)

USNC 142
ILL. 96

SAMPLE D24/A0
TEST DATE JUNE 19, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|---|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On cable, 1 in. above steel pipe. |
| 5 | On penetrant interface of cable and steel pipe. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate, 3 in. from penetrant. |
| 8 | On steel plate, 6 in. from penetrant. |
| 9 | On steel plate, 6 in. from penetrant. |
| 10 | On steel plate, 12 in. from penetrant. |
| 11 | On steel plate, 12 in. from penetrant. |
| 12 | On top of cable, on copper conductor. |

USNC142
ILL. 97

U.S. COAST GUARD
 UL Test No. 26 - D24/A0
 86NK8673/USNC142
 6-19-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 86.4 | 83.0 | 82.8 | 82.1 |
| 4: 0 | 177.4 | 141.2 | 113.3 | 92.5 |
| 8: 0 | 275.3 | 253.7 | 105.7 | 105.7 |
| 12: 0 | 443.4 | 366.1 | 265.2 | 133.6 |
| 16: 0 | 547.9 | 462.2 | 314.8 | 156.3 |
| 20: 0 | 640.7 | 556.4 | 352.1 | 185.7 |
| 24: 0 | 847.3 | 757.2 | 379.2 | 219.3 |
| 28: 0 | 717.8 | 645.5 | 410.5 | 243.6 |
| 32: 0 | 707.6 | 621.7 | 436.0 | 264.3 |
| 36: 0 | 731.9 | 644.4 | 461.9 | 290.3 |
| 40: 0 | 754.5 | 666.2 | 481.2 | 314.1 |
| 44: 0 | 775.9 | 689.6 | 505.4 | 342.2 |
| 48: 0 | 789.6 | 707.5 | 521.8 | 366.1 |
| 52: 0 | 803.6 | 724.8 | 539.1 | 396.4 |
| 56: 0 | 817.5 | 741.5 | 554.4 | 450.7 |
| 60: 0 | 828.9 | 752.6 | 564.3 | 486.3 |

FILE USNC142
 ILL. 98

U.S. COAST GUARD
 UL Test No. 26 - D24/A0
 86NK8673/USNC142
 6-19-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|--------|--------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 81.9 | 80.9 | 110.3 | 108.4 |
| 4: 0 | 88.6 | 86.8 | 655.3 | 583.4 |
| 8: 0 | 103.7 | 101.6 | 1111.7 | 1025.4 |
| 12: 0 | 145.1 | 124.7 | 1217.0 | 1156.8 |
| 16: 0 | 178.0 | 140.6 | 1282.5 | 1228.5 |
| 20: 0 | 237.5 | 157.2 | 1309.3 | 1258.8 |
| 24: 0 | 263.6 | 176.2 | 1339.8 | 1301.9 |
| 28: 0 | 282.5 | 197.4 | 1366.8 | 1334.8 |
| 32: 0 | 303.6 | 223.7 | 1395.6 | 1370.7 |
| 36: 0 | 333.7 | 241.7 | 1419.1 | 1398.0 |
| 40: 0 | 358.7 | 255.2 | 1434.2 | 1420.4 |
| 44: 0 | 389.7 | 271.3 | 1445.5 | 1440.3 |
| 48: 0 | 436.7 | 286.3 | 1463.7 | 1462.6 |
| 52: 0 | 503.5 | 302.1 | 1483.4 | 1491.7 |
| 56: 0 | 559.5 | 317.7 | 1499.5 | 1510.4 |
| 60: 0 | 675.2 | 326.3 | 1526.0 | 1527.2 |

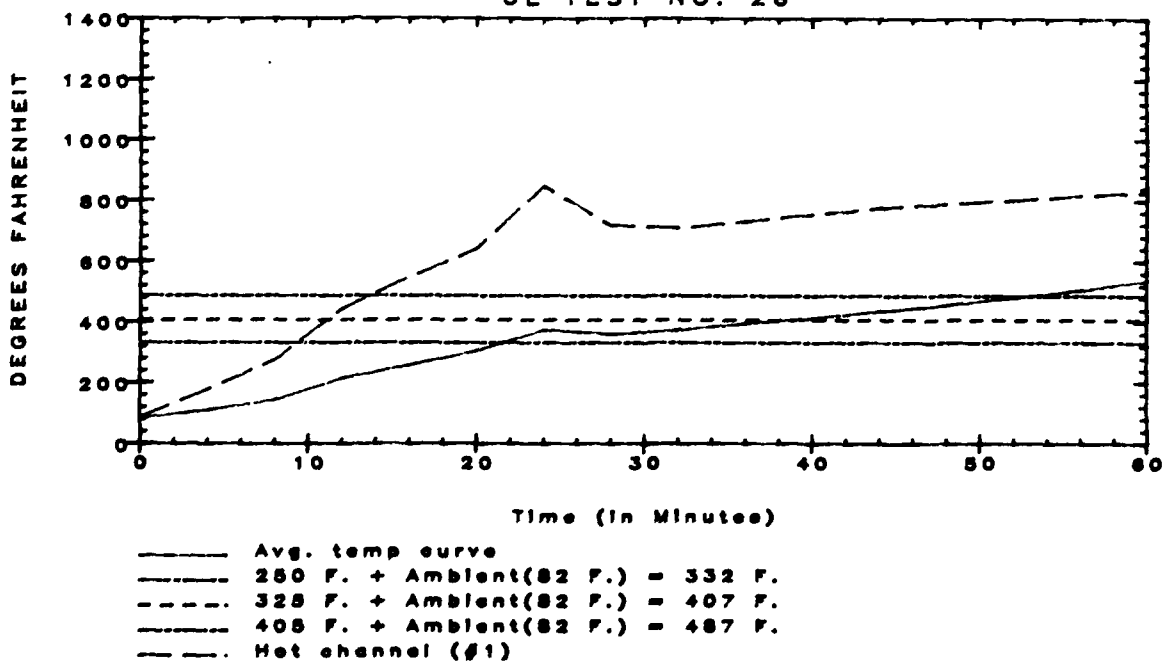
FILE USNC142
 ILL. 98A

U.S. COAST GUARD
UL Test No. 26 - D24/A0
86NK8673/USNC142
6-19-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|--------|--------|--------|-------|
| TIME | | | | |
| 0: 0 | 110.3 | 108.9 | 107.3 | 81.0 |
| 4: 0 | 655.9 | 721.9 | 531.8 | 85.9 |
| 8: 0 | 1117.0 | 1193.4 | 954.2 | 191.5 |
| 12: 0 | 1230.4 | 1275.7 | 1104.6 | 109.9 |
| 16: 0 | 1295.4 | 1328.5 | 1180.2 | 120.1 |
| 20: 0 | 1332.2 | 1359.2 | 1235.1 | 133.8 |
| 24: 0 | 1366.3 | 1397.2 | 1276.2 | 149.4 |
| 28: 0 | 1399.9 | 1434.2 | 1311.8 | 168.6 |
| 32: 0 | 1436.7 | 1469.1 | 1351.6 | 191.1 |
| 36: 0 | 1458.0 | 1500.7 | 1380.9 | 204.8 |
| 40: 0 | 1477.9 | 1523.7 | 1402.6 | 205.9 |
| 44: 0 | 1494.4 | 1547.9 | 1425.5 | 222.2 |
| 48: 0 | 1511.3 | 1570.4 | 1447.0 | 228.1 |
| 52: 0 | 1540.2 | 1593.1 | 1469.8 | 236.0 |
| 56: 0 | 1564.6 | 1603.6 | 1485.8 | 240.7 |
| 60: 0 | 1579.1 | 1604.1 | 1494.3 | 250.1 |

SAMPLE D24/A0
UL TEST NO. 26



T E S T R E C O R D D25/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D25/A60E and as shown in ILL. 99.

The fire and hose stream tests were conducted on June 5, 1986 and identified by UL as Test No. 4.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations *</u> |
|-----------------------|---|
| 45 | Steam issued from the top of the duct. The duct gasket material was melting and dripping. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 100.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 101 through 101B.

HOSE STREAM TEST:

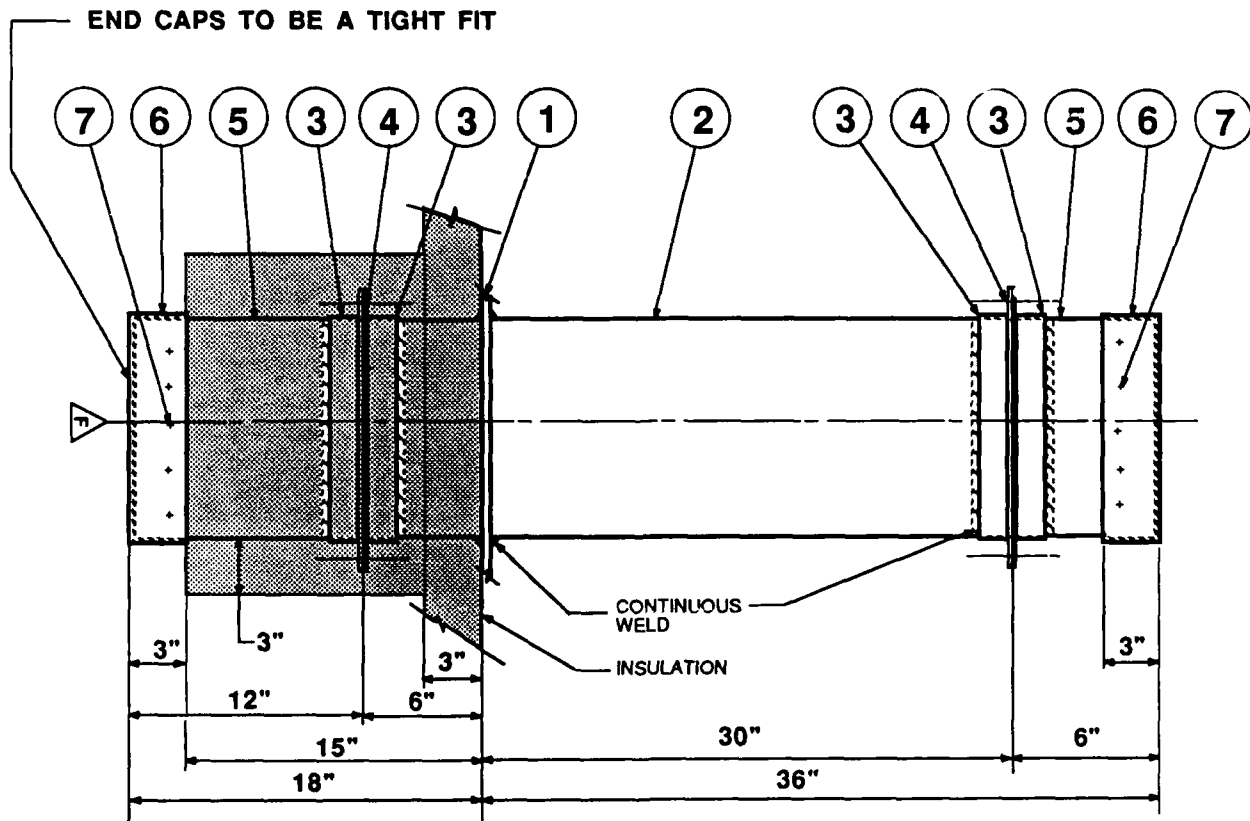
No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

* A review of the above photographic documentation shows that smoke, recorded in the above observation, did not pass through the penetrant.

D25/A60E
UL TEST NO. 4

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② STEEL SPIGOT, 12" X 12" X 1/8" THICK,
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ③ 1-1/2" X 1-1/2" X 1/8" STEEL ANGLE BAR,
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ④ 3/8" DIA STEEL BOLTS, NUTS, AND WASHERS
@ 4" SPACING.
- ⑤ 12" X 12" X 22G STEEL VENT DUCT
- ⑥ STEEL EXTERIOR CAP, 22G
- ⑦ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP).



TEST SAMPLE D-25A
VENT DUCT WITH
STEEL SPIGOT (RECT)

USNC 142
ILL. 99

SAMPLE D25/A60E
TEST DATE JUNE 5, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at overlap of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate over insulation, 3 in. from penetrant. |
| 8 | On steel plate over insulation, 4 in. from penetrant. |
| 9 | On steel plate over insulation seam, 4 in. from penetrant. |
| 10 | On steel plate over insulation, 8 in. from penetrant. |
| 11 | On steel plate over insulation seam, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 100

U.S. COAST GUARD
 UL Test No. 4 - D25/A60E
 86NK8673/USNC142
 6-5-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 70.2 | 69.9 | 70.1 | 68.9 |
| 4: 0 | 84.1 | 82.9 | 79.3 | 77.4 |
| 8: 0 | 119.7 | 115.6 | 105.7 | 94.1 |
| 12: 0 | 167.9 | 161.0 | 142.0 | 115.2 |
| 16: 0 | 213.5 | 204.4 | 178.4 | 137.9 |
| 20: 0 | 255.8 | 245.3 | 213.4 | 159.3 |
| 24: 0 | 296.0 | 282.8 | 245.0 | 180.2 |
| 28: 0 | 334.5 | 318.4 | 274.9 | 201.3 |
| 32: 0 | 374.8 | 354.8 | 306.3 | 224.0 |
| 36: 0 | 408.1 | 387.3 | 334.3 | 246.8 |
| 40: 0 | 442.5 | 417.8 | 359.7 | 266.6 |
| 44: 0 | 476.3 | 448.0 | 383.4 | 284.8 |
| 48: 0 | 503.5 | 472.2 | 402.3 | 298.0 |
| 52: 0 | 531.4 | 494.4 | 417.9 | 307.8 |
| 56: 0 | 559.0 | 516.5 | 430.6 | 316.7 |
| 60: 0 | 582.2 | 536.0 | 443.2 | 324.0 |

FILE USNC142
 ILL. 101

U.S. COAST GUARD
UL Test No. 4 - D25/A60E
86NK8673/USNC142
6-5-86

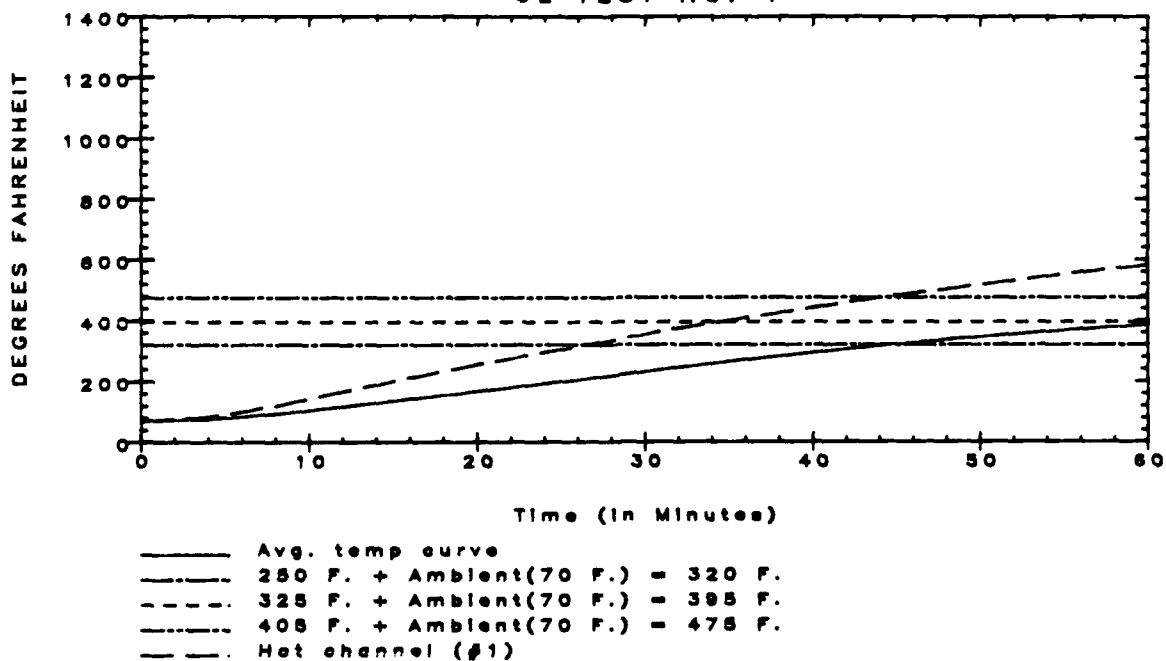
| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 69.0 | 69.0 | 70.1 | 70.3 |
| 4: 0 | 77.6 | 77.6 | 70.9 | 71.8 |
| 8: 0 | 99.5 | 95.1 | 80.8 | 76.0 |
| 12: 0 | 130.1 | 120.7 | 97.5 | 89.6 |
| 16: 0 | 161.9 | 147.9 | 120.4 | 105.7 |
| 20: 0 | 192.6 | 175.1 | 144.3 | 124.9 |
| 24: 0 | 221.8 | 200.2 | 169.0 | 146.2 |
| 28: 0 | 248.4 | 225.0 | 194.8 | 169.2 |
| 32: 0 | 277.4 | 250.7 | 222.6 | 193.9 |
| 36: 0 | 303.3 | 275.0 | 250.9 | 219.8 |
| 40: 0 | 327.5 | 296.3 | 276.2 | 247.5 |
| 44: 0 | 347.8 | 315.2 | 302.0 | 272.6 |
| 48: 0 | 365.0 | 330.0 | 325.8 | 296.5 |
| 52: 0 | 379.0 | 341.9 | 348.3 | 318.2 |
| 56: 0 | 390.2 | 350.0 | 369.5 | 338.6 |
| 60: 0 | 396.7 | 357.2 | 388.6 | 357.1 |

FILE USNC142
ILL. 101A

U.S. COAST GUARD
UL Test No. 4 - D25/A60E
86NK8673/USNC142
6-5-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 70.5 | 70.0 | 70.3 | 69.0 |
| 4: 0 | 71.1 | 71.4 | 70.7 | 91.5 |
| 8: 0 | 74.8 | 73.5 | 72.2 | 124.6 |
| 12: 0 | 83.9 | 78.1 | 76.5 | 159.8 |
| 16: 0 | 96.0 | 85.5 | 83.5 | 187.7 |
| 20: 0 | 111.5 | 94.7 | 92.4 | 213.4 |
| 24: 0 | 129.5 | 108.1 | 106.3 | 235.4 |
| 28: 0 | 149.4 | 124.0 | 122.2 | 259.4 |
| 32: 0 | 171.2 | 140.2 | 139.5 | 292.4 |
| 36: 0 | 194.6 | 156.2 | 155.7 | 314.5 |
| 40: 0 | 217.9 | 175.2 | 174.2 | 333.6 |
| 44: 0 | 240.7 | 194.1 | 194.2 | 350.3 |
| 48: 0 | 262.3 | 213.3 | 213.0 | 364.0 |
| 52: 0 | 282.5 | 229.4 | 230.1 | 378.5 |
| 56: 0 | 301.5 | 244.7 | 245.7 | 395.2 |
| 60: 0 | 318.1 | 258.6 | 259.8 | 411.7 |

SAMPLE D25/A60E
UL TEST NO. 4



T E S T R E C O R D D25/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D25/A60U and as shown in ILL. 102.

The fire and hose stream tests were conducted on June 16, 1986 and identified by UL as Test No. 19.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 3 | Steam issued from the gasket at the interface of the duct and spigot. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 103.

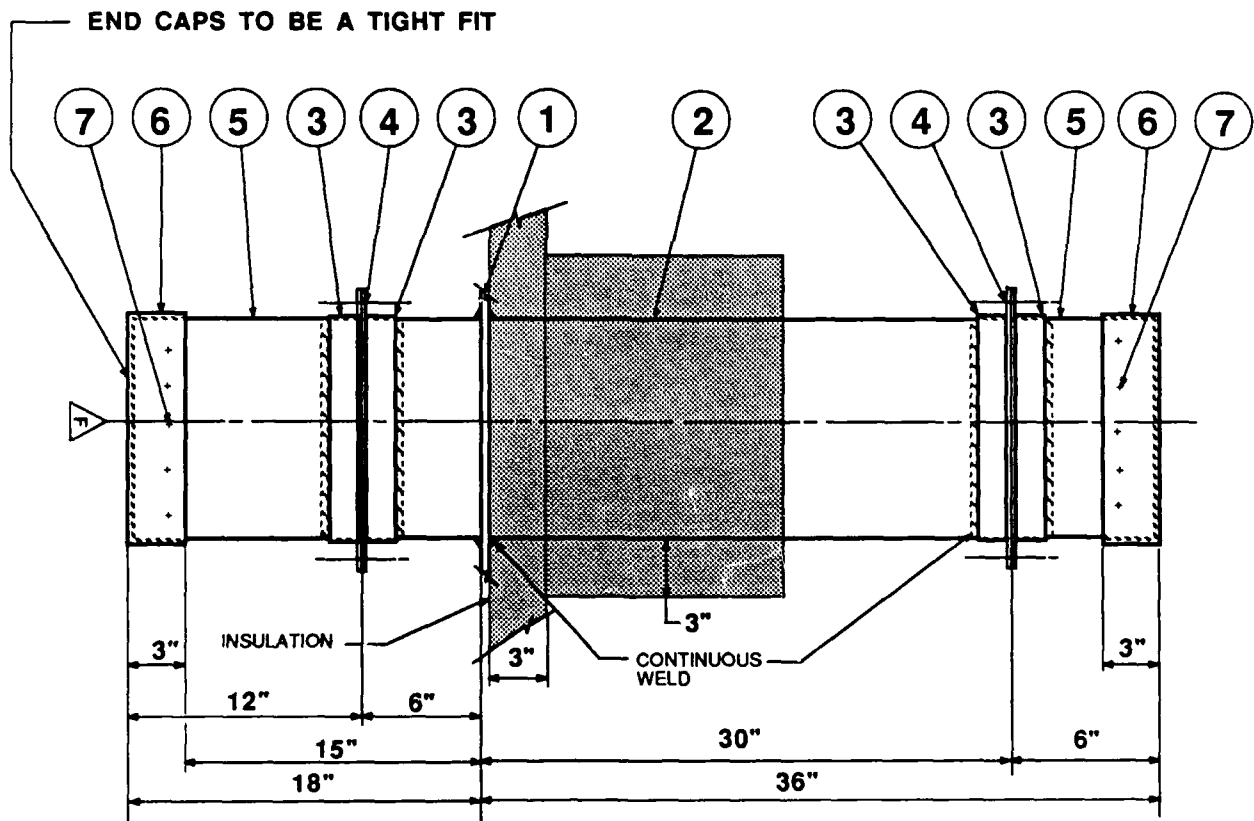
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 104 through 104B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② STEEL SPIGOT, 12" X 12" X 1/8" THICK,
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ③ 1-1/2" X 1-1/2" X 1/8" STEEL ANGLE BAR,
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ④ 3/8" DIA STEEL BOLTS, NUTS, AND WASHERS
@ 4" SPACING.
- ⑤ 12" X 12" X 22G STEEL VENT DUCT
- ⑥ STEEL EXTERIOR CAP, 22G
- ⑦ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP).



TEST SAMPLE D-25A
VENT DUCT WITH
STEEL SPIGOT (RECT)
(R&DC GRAPHIC 27)

USNC 142
ILL.102

SAMPLE D25/A60U
TEST DATE JUNE 16, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at overlap of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate insulation, at interface of penetrant insulation. |
| 8 | On steel plate insulation, 4 in. from penetrant. |
| 9 | On steel plate insulation seam, 4 in. from penetrant. |
| 10 | On steel plate insulation, 8 in. from penetrant. |
| 11 | On steel plate insulation seam, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 103

U.S. COAST GUARD
 UL Test No. 19 - D25/A60U
 86NK8673/USNC142
 6-16-86

Temperature Degrees F

| CHAN(NOS.) | 1 | 2 | 3 | 4 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 79.7 | 79.0 | 80.2 | 79.2 |
| 4: 0 | 80.7 | 81.1 | 79.5 | 97.5 |
| 8: 0 | 82.0 | 83.8 | 81.6 | 171.6 |
| 12: 0 | 87.3 | 85.7 | 84.6 | 225.4 |
| 16: 0 | 93.4 | 88.0 | 86.0 | 275.5 |
| 20: 0 | 96.1 | 93.5 | 89.1 | 319.6 |
| 24: 0 | 108.5 | 97.2 | 92.5 | 355.2 |
| 28: 0 | 148.6 | 103.3 | 97.3 | 385.6 |
| 32: 0 | 227.4 | 114.0 | 103.9 | 412.2 |
| 36: 0 | 322.0 | 130.2 | 113.8 | 429.9 |
| 40: 0 | 411.3 | 154.0 | 128.2 | 449.1 |
| 44: 0 | 485.7 | 187.2 | 147.5 | 460.0 |
| 48: 0 | 540.7 | 232.0 | 171.3 | 467.0 |
| 52: 0 | 579.6 | 288.4 | 198.6 | 470.9 |
| 56: 0 | 606.3 | 344.0 | 227.9 | 476.2 |
| 60: 0 | 624.5 | 385.0 | 256.1 | 483.2 |

FILE USNC142
 ILL. 104

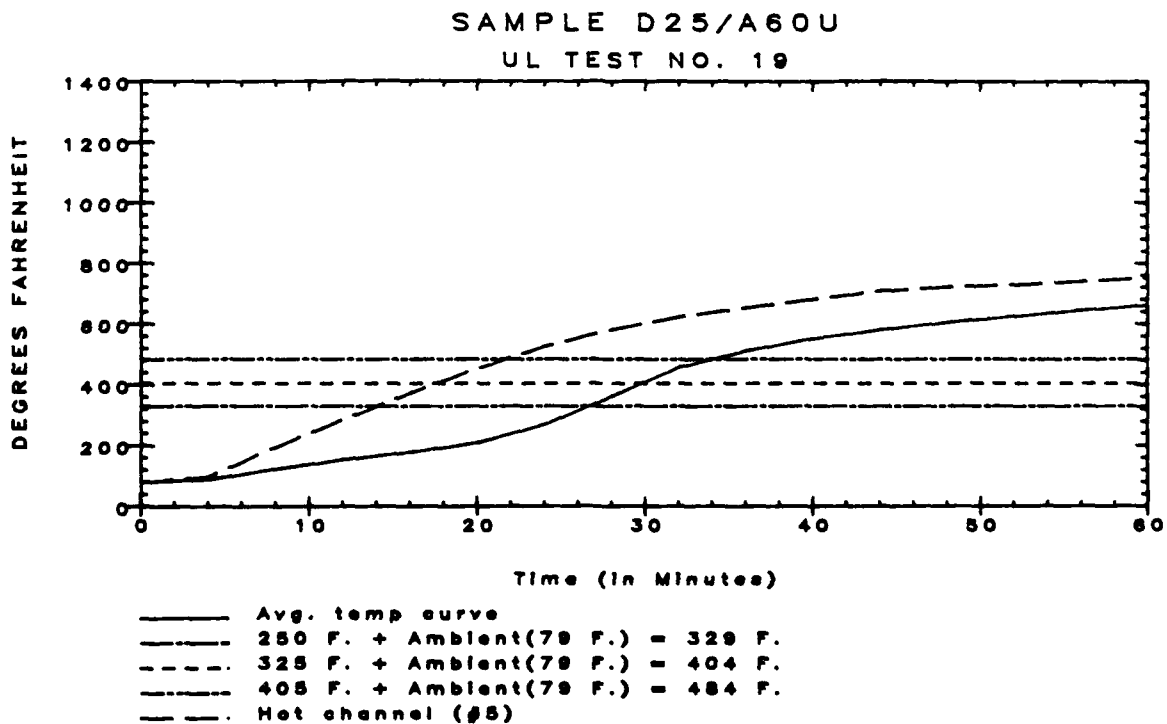
U.S. COAST GUARD
 UL Test No. 19 - D25/A60U
 86NK8673/USNC142
 6-16-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|--------|-------|
| CHAN(NDS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 78.7 | 78.9 | 78.3 | 79.0 |
| 4: 0 | 98.1 | 97.2 | 78.7 | 80.9 |
| 8: 0 | 194.4 | 180.9 | 81.7 | 83.9 |
| 12: 0 | 285.0 | 252.2 | 96.5 | 102.9 |
| 16: 0 | 372.7 | 320.4 | 108.1 | 98.7 |
| 20: 0 | 453.7 | 381.1 | 121.1 | 129.1 |
| 24: 0 | 526.0 | 434.7 | 280.2 | 218.0 |
| 28: 0 | 582.0 | 476.1 | 618.3 | 390.9 |
| 32: 0 | 623.2 | 507.0 | 943.6 | 551.1 |
| 36: 0 | 652.9 | 528.7 | 996.1 | 640.4 |
| 40: 0 | 681.8 | 551.4 | 1038.6 | 689.3 |
| 44: 0 | 708.4 | 568.8 | 1071.9 | 721.2 |
| 48: 0 | 722.0 | 579.6 | 1097.1 | 743.9 |
| 52: 0 | 729.0 | 583.3 | 1117.4 | 764.4 |
| 56: 0 | 739.5 | 592.5 | 1137.0 | 781.3 |
| 60: 0 | 752.1 | 601.8 | 1155.0 | 794.7 |

FILE USNC142
 ILL. 104A

U.S. COAST GUARD
 UL Test No. 19 - D25/A60U
 86NK8673/USNC142
 6-16-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 9 | 10 | 11 | 12 |
| TIME | | | | |
| 0: 0 | 79.4 | 80.2 | 80.1 | 80.2 |
| 4: 0 | 80.5 | 80.6 | 80.9 | 155.5 |
| 8: 0 | 84.7 | 83.6 | 82.0 | 265.4 |
| 12: 0 | 98.2 | 93.4 | 89.6 | 333.6 |
| 16: 0 | 107.9 | 99.3 | 94.7 | 388.3 |
| 20: 0 | 144.4 | 155.7 | 96.7 | 430.5 |
| 24: 0 | 242.1 | 287.1 | 117.9 | 463.5 |
| 28: 0 | 420.3 | 464.7 | 168.3 | 490.1 |
| 32: 0 | 666.9 | 583.3 | 242.3 | 510.9 |
| 36: 0 | 850.9 | 635.9 | 312.5 | 521.2 |
| 40: 0 | 934.7 | 667.2 | 359.3 | 557.1 |
| 44: 0 | 974.9 | 691.9 | 389.1 | 580.7 |
| 48: 0 | 1003.6 | 713.6 | 410.9 | 586.3 |
| 52: 0 | 1025.8 | 732.6 | 429.7 | 584.3 |
| 56: 0 | 1042.9 | 748.3 | 446.8 | 595.5 |
| 60: 0 | 1057.1 | 759.9 | 463.5 | 605.5 |



T E S T R E C O R D D25/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D25/A0 and as shown in ILL. 105.

The fire and hose stream tests were conducted on June 10, 1986 and identified by UL as Test No. 9.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 2 | The gasket material on the exposed side was melting and dripping into the furnace. |
| 9 | The steel plate turned black in color. Steam was issued from the gasket. |
| 19 | The steel plate was bowing downward. |
| 34 | The steel plate was glowing red. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 106.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 107 through 107B.

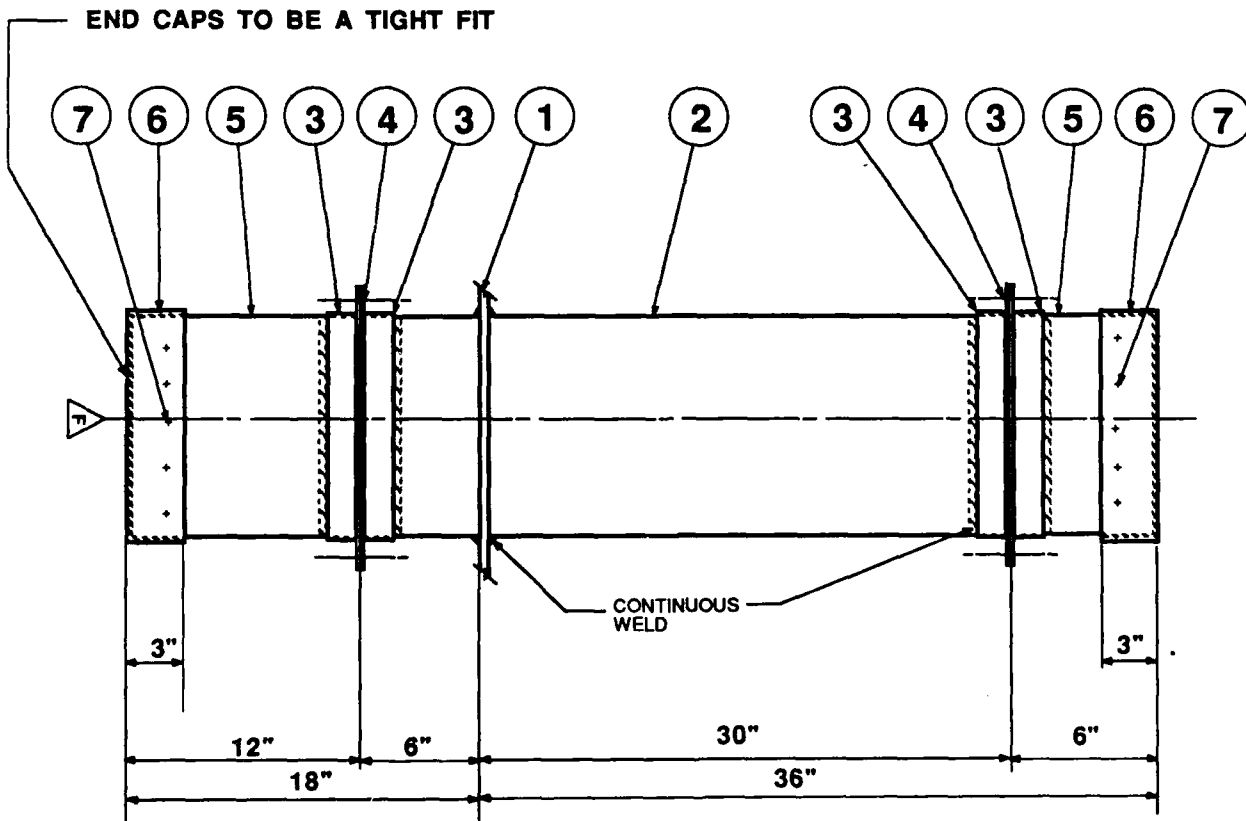
HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D25/AO
UL TEST NO. 9

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② STEEL SPIGOT, 12" X 12" X 1/8" THICK,
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ③ 1-1/2" X 1-1/2" X 1/8" STEEL ANGLE BAR,
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ④ 3/8" DIA STEEL BOLTS, NUTS, AND WASHERS
@ 4" SPACING.
- ⑤ 12" X 12" X 22G STEEL VENT DUCT
- ⑥ STEEL EXTERIOR CAP, 22G
- ⑦ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP).



TEST SAMPLE D-25A
VENT DUCT WITH
STEEL SPIGOT (RECT)
(R&DC GRAPHIC 26A)

USNC 142
ILL.105

SAMPLE D25/A0
TEST DATE JUNE 10, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at overlap of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate, 3 in. from penetrant. |
| 8 | On steel plate, 4 in. from penetrant. |
| 9 | On steel plate, 4 in. from penetrant. |
| 10 | On steel plate, 8 in. from penetrant. |
| 11 | On steel plate, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 106

U.S. COAST GUARD
 UL Test No. 9 - D25/A0
 86NK8673/USNC142
 6-10-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 77.5 | 77.1 | 76.5 | 74.0 |
| 4: 0 | 143.3 | 116.7 | 105.4 | 75.3 |
| 8: 0 | 323.4 | 265.1 | 207.6 | 75.1 |
| 12: 0 | 541.7 | 463.1 | 348.7 | 76.0 |
| 16: 0 | 702.4 | 621.9 | 471.2 | 77.4 |
| 20: 0 | 799.4 | 722.0 | 554.5 | 78.4 |
| 24: 0 | 838.5 | 774.8 | 602.6 | 79.2 |
| 28: 0 | 874.4 | 811.1 | 638.0 | 80.6 |
| 32: 0 | 904.4 | 840.7 | 664.7 | 82.5 |
| 36: 0 | 932.5 | 865.3 | 689.0 | 82.7 |
| 40: 0 | 949.0 | 882.2 | 704.4 | 83.5 |
| 44: 0 | 966.5 | 899.1 | 717.5 | 82.8 |
| 48: 0 | 982.1 | 912.6 | 732.1 | 83.4 |
| 52: 0 | 995.2 | 924.1 | 742.5 | 84.9 |
| 56: 0 | 1005.3 | 933.2 | 748.1 | 84.6 |
| 60: 0 | 1018.4 | 945.7 | 758.8 | 86.8 |

FILE USNC142
 ILL. 107

U.S. COAST GUARD
 UL Test No. 9 - D25/A0
 86NK8673/USNC142
 6-10-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|--------|--------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 75.2 | 75.0 | 77.7 | 78.7 |
| 4: 0 | 99.1 | 94.2 | 422.5 | 384.7 |
| 8: 0 | 176.0 | 156.1 | 766.8 | 726.6 |
| 12: 0 | 276.2 | 235.7 | 1059.8 | 1008.4 |
| 16: 0 | 370.9 | 308.4 | 1174.1 | 1137.7 |
| 20: 0 | 438.3 | 362.6 | 1247.8 | 1213.4 |
| 24: 0 | 479.3 | 401.0 | 1289.9 | 1257.2 |
| 28: 0 | 508.7 | 428.3 | 1327.0 | 1297.3 |
| 32: 0 | 535.9 | 449.1 | 1364.2 | 1334.7 |
| 36: 0 | 555.9 | 465.9 | 1401.6 | 1372.7 |
| 40: 0 | 570.6 | 477.0 | 1428.9 | 1401.7 |
| 44: 0 | 580.7 | 484.2 | 1453.0 | 1427.5 |
| 48: 0 | 593.1 | 492.8 | 1474.2 | 1449.6 |
| 52: 0 | 601.2 | 500.0 | 1491.4 | 1468.0 |
| 56: 0 | 608.2 | 506.0 | 1508.1 | 1487.4 |
| 60: 0 | 614.5 | 508.1 | 1520.1 | 1501.9 |

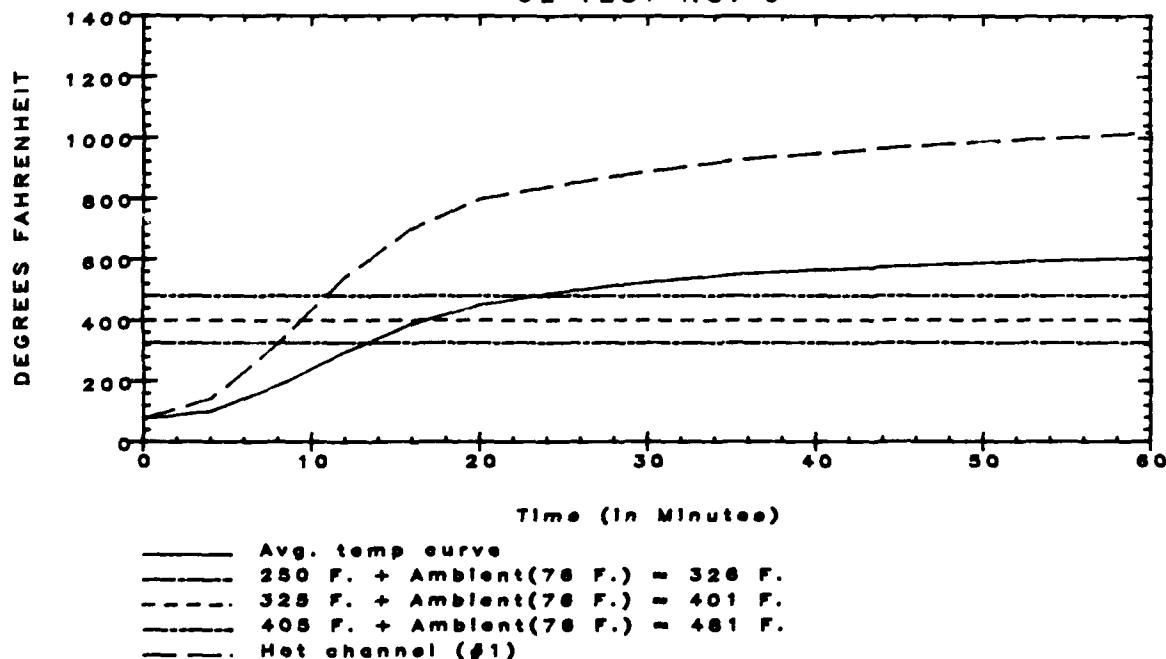
FILE USNC142
 ILL. 107A

U.S. COAST GUARD
 UL Test No. 9 - D25/A0
 86NK8673/USNC142
 6-10-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|--------|--------|--------|-------|
| TIME | | | | |
| 0: 0 | 79.4 | 78.8 | 77.5 | 75.9 |
| 4: 0 | 462.4 | 409.7 | 382.0 | 127.6 |
| 8: 0 | 854.2 | 719.4 | 698.8 | 229.3 |
| 12: 0 | 1089.7 | 961.6 | 929.2 | 290.4 |
| 16: 0 | 1190.6 | 1082.9 | 1041.8 | 332.0 |
| 20: 0 | 1241.4 | 1159.2 | 1102.1 | 361.1 |
| 24: 0 | 1269.0 | 1200.3 | 1138.0 | 401.8 |
| 28: 0 | 1318.5 | 1245.9 | 1181.5 | 413.1 |
| 32: 0 | 1351.7 | 1285.7 | 1216.8 | 430.2 |
| 36: 0 | 1383.3 | 1316.3 | 1246.6 | 440.5 |
| 40: 0 | 1408.4 | 1340.5 | 1275.2 | 450.0 |
| 44: 0 | 1429.0 | 1362.8 | 1298.1 | 459.0 |
| 48: 0 | 1453.7 | 1380.7 | 1320.2 | 470.7 |
| 52: 0 | 1468.4 | 1396.8 | 1335.7 | 469.4 |
| 56: 0 | 1485.2 | 1412.6 | 1351.7 | 471.3 |
| 60: 0 | 1503.3 | 1426.9 | 1370.8 | 471.7 |

SAMPLE D25/A0
 UL TEST NO. 9



T E S T R E C O R D D26/A60USAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D26/A60U and as shown in ILL. 108.

The fire and hose stream tests were conducted on June 14, 1986 and identified by UL as Test No. 18.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 5 | Steam issued from the top of the duct. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 109.

The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 110 through 110B.

Pressure Record - At the start of the fire test, the pressure within the small-scale test furnace was -0.01 in./H₂O (-2.5 Pa). Within 30 seconds, the pressure was +0.005 in./H₂O (+1.24 Pa). Throughout the remainder of the fire test, the pressure recorded +0.01 in./H₂O (+2.5 Pa).

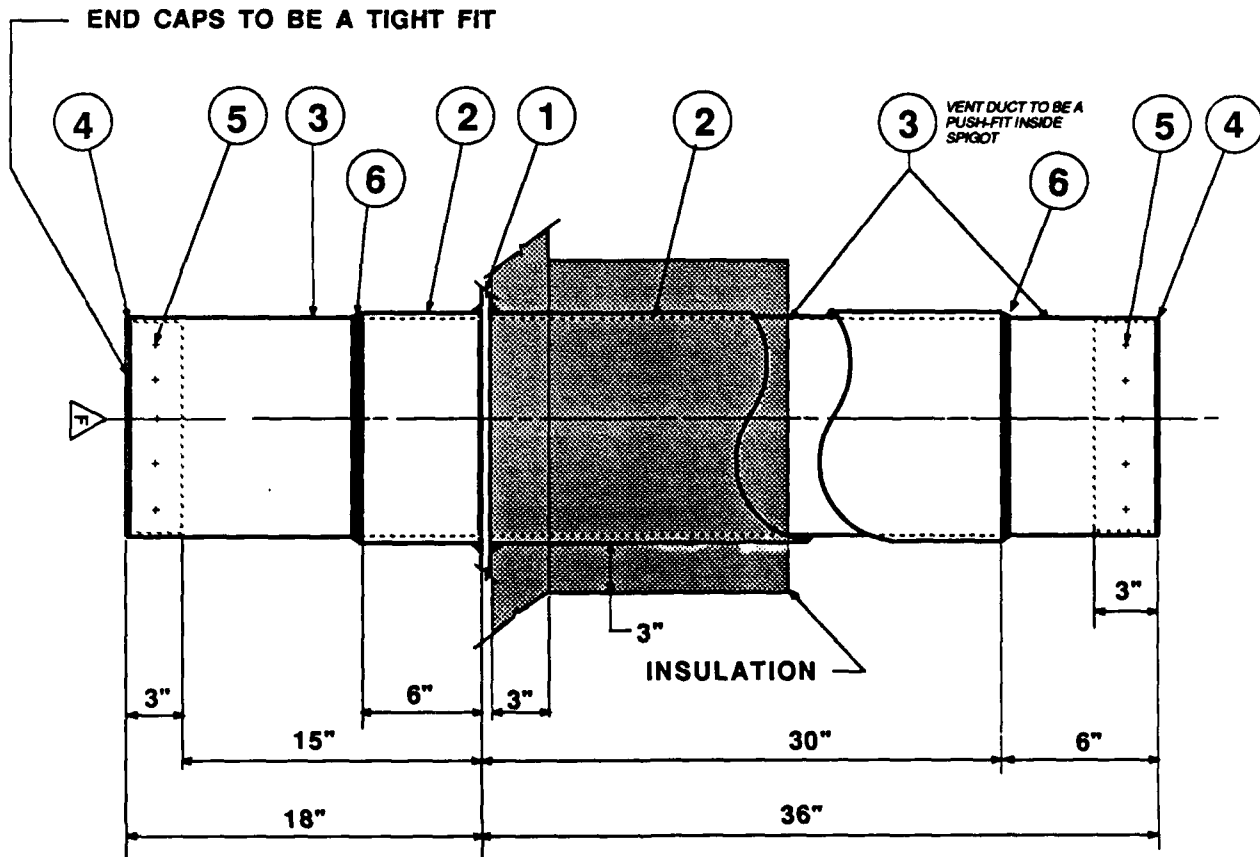
HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

D26/A60U
UL TEST NO. 18

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT)
- ② STEEL SPIGOT, 12-1/2" INSIDE DIAMETER X 1/8" THICK,
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ③ 12" NOMINAL DIAMETER, STEEL SPIRAL-WOUND, VENT
DUCT (SPIRO METAL 24G OR EQUIVALENT).
- ④ STEEL INTERIOR CAP, 24G.
- ⑤ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP).
- ⑥ FIRE RESISTANT SEALANT,



TEST SAMPLE D-26A VENT DUCT
PASSING THROUGH STEEL SPIGOT
(R&DC GRAPHIC 30)

USNC 142
ILL. 108

SAMPLE D26/A60U
TEST DATE JUNE 14, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at interface of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | At interface of steel plate insulation and penetrant insulation. |
| 8 | On steel plate insulation, 4 in. from penetrant. |
| 9 | On steel plate insulation seam, 4 in. from penetrant. |
| 10 | On steel plate insulation, 8 in. from penetrant. |
| 11 | On steel plate insulation seam, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 109

U.S. COAST GUARD
 UL Test No. 18 - D26/A60U
 86NK8673/USNC142
 6-14-86

Temperature Degrees F

| CHAN(NOS.) | 1 | 2 | 3 | 4 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 71.6 | 72.3 | 70.9 | 72.0 |
| 4: 0 | 72.5 | 72.6 | 71.2 | 77.4 |
| 8: 0 | 73.6 | 73.9 | 73.2 | 100.1 |
| 12: 0 | 76.8 | 76.1 | 74.6 | 154.7 |
| 16: 0 | 83.2 | 78.7 | 76.2 | 197.4 |
| 20: 0 | 89.3 | 82.9 | 77.5 | 242.3 |
| 24: 0 | 93.1 | 90.9 | 80.9 | 285.3 |
| 28: 0 | 109.1 | 105.4 | 83.8 | 323.0 |
| 32: 0 | 172.6 | 127.3 | 90.7 | 357.0 |
| 36: 0 | 260.8 | 150.4 | 96.6 | 386.0 |
| 40: 0 | 374.4 | 178.3 | 105.8 | 413.5 |
| 44: 0 | 498.3 | 214.7 | 117.1 | 438.6 |
| 48: 0 | 564.6 | 263.2 | 129.8 | 459.7 |
| 52: 0 | 585.5 | 314.8 | 147.6 | 479.2 |
| 56: 0 | 587.0 | 353.6 | 169.5 | 497.0 |
| 60: 0 | 594.4 | 376.4 | 195.2 | 513.7 |

FILE USNC142
 ILL. 110

U.S. COAST GUARD
 UL Test No. 18 - D26/A60U
 86NK8673/USNC142
 6-14-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 72.0 | 75.2 | 73.1 | 74.4 |
| 4: 0 | 78.3 | 126.2 | 74.2 | 75.4 |
| 8: 0 | 104.1 | 222.8 | 76.7 | 77.5 |
| 12: 0 | 160.0 | 311.0 | 84.0 | 82.8 |
| 16: 0 | 220.1 | 367.5 | 93.6 | 90.5 |
| 20: 0 | 279.6 | 409.4 | 101.6 | 95.6 |
| 24: 0 | 335.7 | 434.6 | 140.6 | 123.2 |
| 28: 0 | 384.2 | 461.7 | 239.2 | 184.6 |
| 32: 0 | 429.4 | 489.4 | 389.2 | 276.2 |
| 36: 0 | 471.5 | 515.9 | 521.6 | 370.6 |
| 40: 0 | 513.0 | 539.8 | 620.7 | 439.7 |
| 44: 0 | 554.4 | 561.0 | 673.7 | 482.1 |
| 48: 0 | 592.2 | 580.8 | 699.4 | 511.2 |
| 52: 0 | 624.0 | 594.7 | 718.2 | 536.4 |
| 56: 0 | 649.6 | 606.6 | 734.6 | 558.7 |
| 60: 0 | 667.9 | 617.0 | 749.8 | 579.3 |

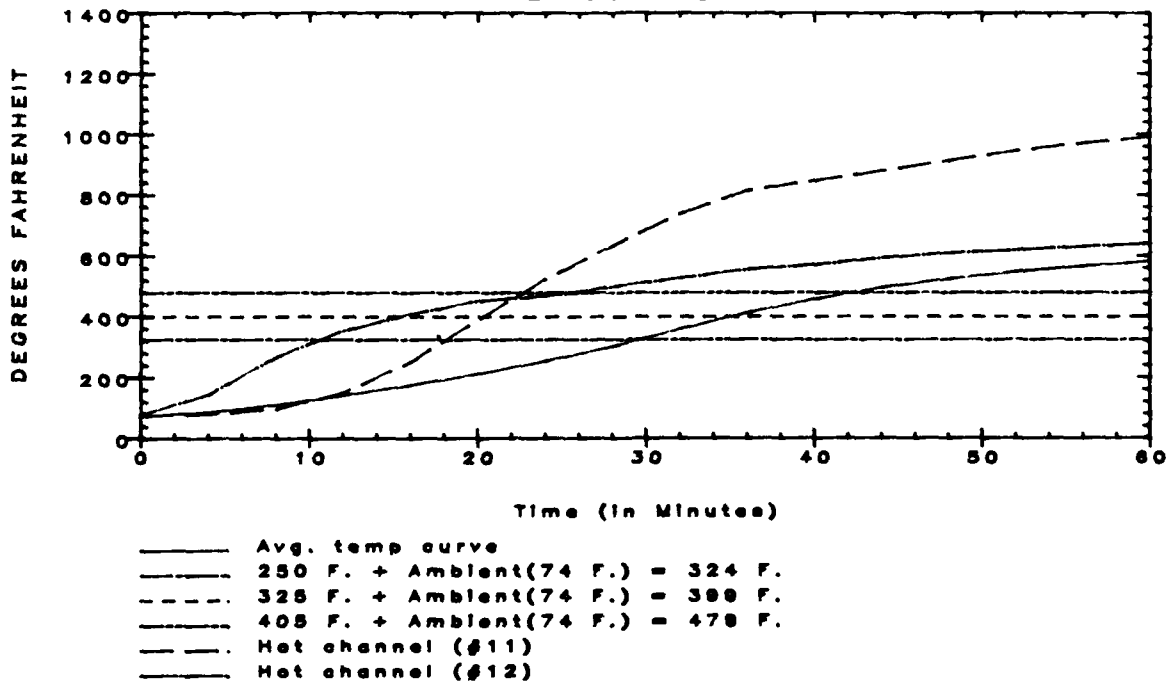
FILE USNC142
 ILL. 110A

U.S. COAST GUARD
 UL Test No. 18 - D26/A60U
 86NK8673/USNC142
 6-14-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|-------|-------|-------|
| TIME | | | | |
| 0: 0 | 75.9 | 73.9 | 75.2 | 78.1 |
| 4: 0 | 76.0 | 76.4 | 79.6 | 143.9 |
| 8: 0 | 82.1 | 76.6 | 96.9 | 267.6 |
| 12: 0 | 97.9 | 81.2 | 149.5 | 354.5 |
| 16: 0 | 139.1 | 85.3 | 251.3 | 408.1 |
| 20: 0 | 228.1 | 90.5 | 389.7 | 451.9 |
| 24: 0 | 365.7 | 104.9 | 524.2 | 468.4 |
| 28: 0 | 448.5 | 140.5 | 634.2 | 499.9 |
| 32: 0 | 512.8 | 190.9 | 737.4 | 527.4 |
| 36: 0 | 564.1 | 239.5 | 815.5 | 556.6 |
| 40: 0 | 606.0 | 273.5 | 847.9 | 571.3 |
| 44: 0 | 637.1 | 297.5 | 880.3 | 594.0 |
| 48: 0 | 661.1 | 307.9 | 914.3 | 610.1 |
| 52: 0 | 683.6 | 323.0 | 946.1 | 619.9 |
| 56: 0 | 704.3 | 335.0 | 971.6 | 631.5 |
| 60: 0 | 722.4 | 343.6 | 991.9 | 640.5 |

SAMPLE D26/A60U
 UL TEST NO. 18



T E S T R E C O R D D26/A60ESAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D26/A60E and as shown in ILL. 111.

The fire and hose stream tests were conducted on June 18, 1986 and identified by UL as Test No. 23.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 41 | No significant changes had occurred. |
| 42 | Light steam issued from the top of the steel duct. |
| 60 | No other significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 112.

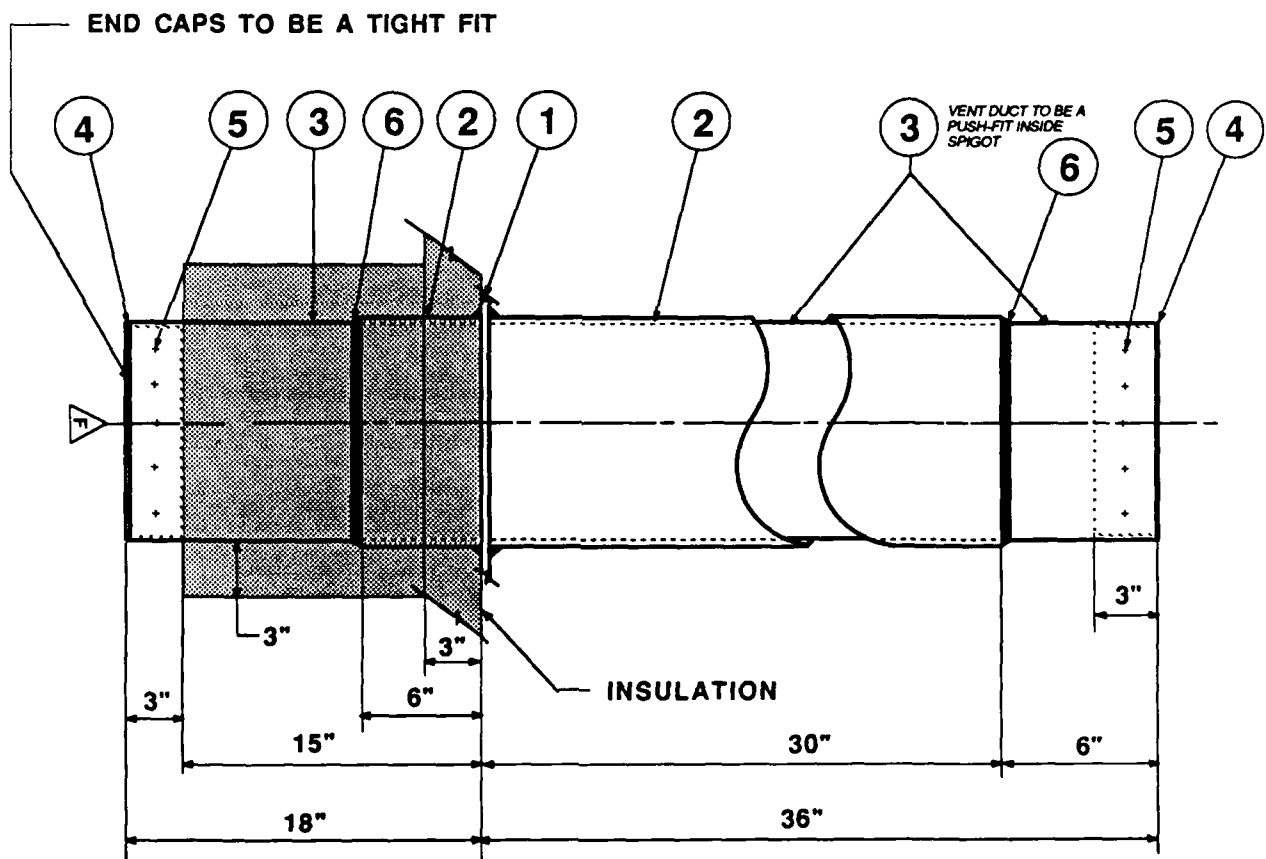
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 113 through 113B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT) .
- ② STEEL SPIGOT, 12-1/2" INSIDE DIAMETER X 1/8" THICK,
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ③ 12" NOMINAL DIAMETER, STEEL SPIRAL-WOUND, VENT
DUCT (SPIRO METAL 24G OR EQUIVALENT).
- ④ STEEL INTERIOR CAP, 24G.
- ⑤ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP).
- ⑥ FIRE RESISTANT SEALANT



TEST SAMPLE D-26A VENT DUCT
PASSING THROUGH STEEL SPIGOT
(R&DC GRAPHIC 29)

USNC 142
ILL. 111

SAMPLE D26/AG0E
TEST DATE JUNE 18, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at interface of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate over insulation, 3 in. from penetrant. |
| 8 | On steel plate over insulation, 4 in. from penetrant. |
| 9 | On steel plate over insulation seam, 4 in. from penetrant. |
| 10 | On steel plate over insulation, 8 in. from penetrant. |
| 11 | On steel plate over insulation seam, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 112

U.S. COAST GUARD
 UL Test No. 23 - D26/A60E
 86NK8673/USNC142
 6-18-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NDS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 77.5 | 71.2 | 76.5 | 74.0 |
| 4: 0 | 73.2 | 72.9 | 72.7 | 72.7 |
| 8: 0 | 82.3 | 81.7 | 80.8 | 116.8 |
| 12: 0 | 116.4 | 102.9 | 99.1 | 157.5 |
| 16: 0 | 138.5 | 136.8 | 128.5 | 198.5 |
| 20: 0 | 177.8 | 175.9 | 163.6 | 233.1 |
| 24: 0 | 220.4 | 218.0 | 200.2 | 262.0 |
| 28: 0 | 260.6 | 257.8 | 236.0 | 288.5 |
| 32: 0 | 301.2 | 296.0 | 269.1 | 310.9 |
| 36: 0 | 338.6 | 332.6 | 298.7 | 330.8 |
| 40: 0 | 374.5 | 365.4 | 324.5 | 347.8 |
| 44: 0 | 410.0 | 398.0 | 347.3 | 358.2 |
| 48: 0 | 441.1 | 426.7 | 367.9 | 368.6 |
| 52: 0 | 466.8 | 449.3 | 385.6 | 380.2 |
| 56: 0 | 490.8 | 471.3 | 401.2 | 387.7 |
| 60: 0 | 510.0 | 487.5 | 414.7 | 398.6 |

FILE USNC142
 ILL. 113

U.S. COAST GUARD
 UL Test No. 23 - D26/A60E
 86NK8673/USNC142
 6-18-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 75.2 | 75.0 | 77.7 | 78.7 |
| 4: 0 | 70.9 | 70.8 | 71.9 | 72.1 |
| 8: 0 | 77.7 | 76.2 | 74.8 | 74.4 |
| 12: 0 | 91.3 | 89.2 | 83.8 | 79.9 |
| 16: 0 | 111.7 | 109.1 | 98.8 | 89.2 |
| 20: 0 | 139.5 | 134.1 | 120.2 | 102.3 |
| 24: 0 | 168.4 | 162.1 | 146.6 | 121.6 |
| 28: 0 | 196.6 | 186.3 | 177.2 | 144.0 |
| 32: 0 | 223.2 | 210.2 | 210.5 | 167.0 |
| 36: 0 | 247.2 | 232.0 | 244.2 | 192.7 |
| 40: 0 | 268.4 | 251.2 | 278.6 | 218.5 |
| 44: 0 | 285.9 | 266.9 | 311.8 | 244.3 |
| 48: 0 | 301.3 | 280.4 | 343.5 | 270.1 |
| 52: 0 | 314.3 | 291.9 | 373.4 | 294.1 |
| 56: 0 | 327.0 | 301.9 | 400.2 | 315.3 |
| 60: 0 | 337.3 | 310.8 | 425.1 | 334.3 |

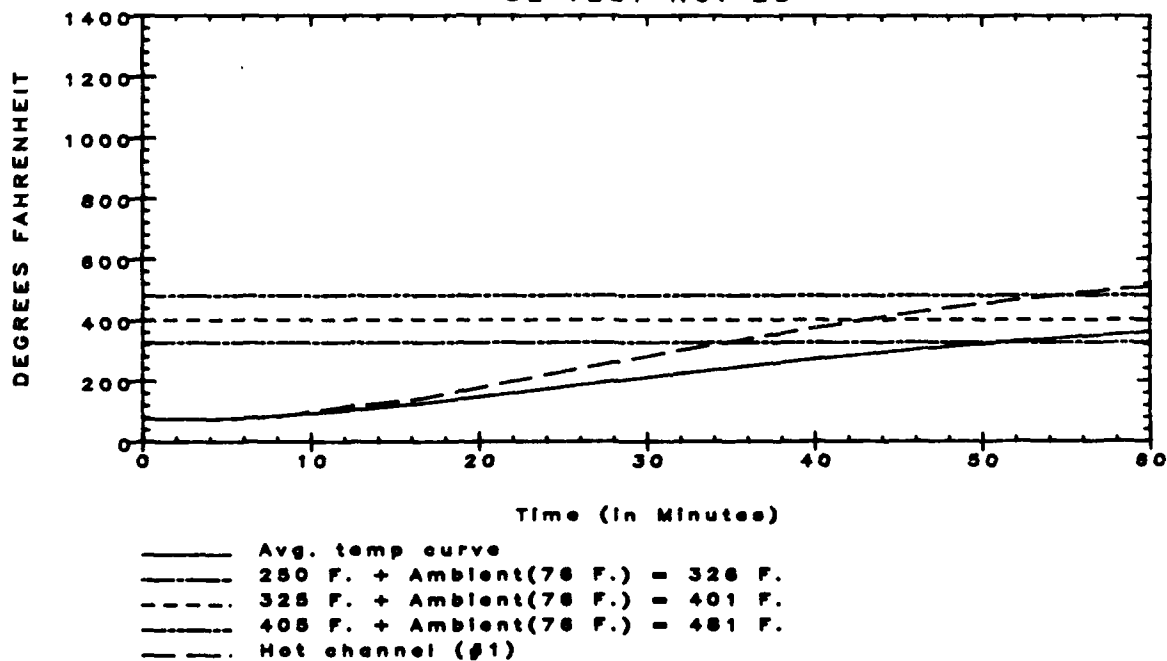
FILE USNC142
 ILL. 113A

U.S. COAST GUARD
 UL Test No. 23 - D26/A60E
 86NK8673/USNC142
 6-18-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|-------|------|-------|-------|
| TIME | | | | |
| 0: 0 | 79.4 | 78.8 | 79.3 | 70.4 |
| 4: 0 | 73.1 | 69.0 | 72.6 | 95.4 |
| 8: 0 | 75.6 | 69.8 | 74.9 | 138.9 |
| 12: 0 | 81.5 | 69.1 | 79.1 | 186.4 |
| 16: 0 | 91.6 | 71.1 | 85.2 | 226.0 |
| 20: 0 | 103.9 | 70.0 | 93.2 | 269.0 |
| 24: 0 | 122.0 | 71.1 | 106.4 | 289.7 |
| 28: 0 | 143.0 | 71.7 | 123.1 | 316.4 |
| 32: 0 | 165.5 | 71.9 | 141.0 | 337.6 |
| 36: 0 | 191.0 | 72.4 | 157.9 | 355.4 |
| 40: 0 | 217.2 | 72.9 | 176.6 | 373.4 |
| 44: 0 | 242.8 | 73.3 | 197.7 | 384.1 |
| 48: 0 | 267.9 | 73.7 | 217.4 | 397.3 |
| 52: 0 | 293.7 | 74.4 | 235.9 | 410.1 |
| 56: 0 | 315.6 | 75.1 | 253.3 | 417.6 |
| 60: 0 | 336.4 | 75.7 | 269.7 | 422.6 |

SAMPLE D26/A60E
 UL TEST NO. 23



T E S T R E C O R D D26/A0SAMPLE:

The fire and hose stream tests were conducted on the assembly identified as D26/A0 and as shown on ILL. 114.

The fire and hose stream tests were conducted on June 11, 1986 and identified by UL as Test No. 11.

RESULTS

Observations During Fire Test - All observations refer to the unexposed surface unless noted.

| <u>Test Time, min</u> | <u>Observations</u> |
|-----------------------|---|
| 7 | The RTV sealant on the exposed side was heavily charred. |
| 12 | The steel plate was black in color. |
| 26 | The steel plate was bowing downward. |
| 60 | No significant changes occurred during the remainder of the fire test. Test terminated. |

Temperature Of The Assembly - The locations of the thermocouples used to measure the various temperatures on the deck assembly are shown in ILL. 115.

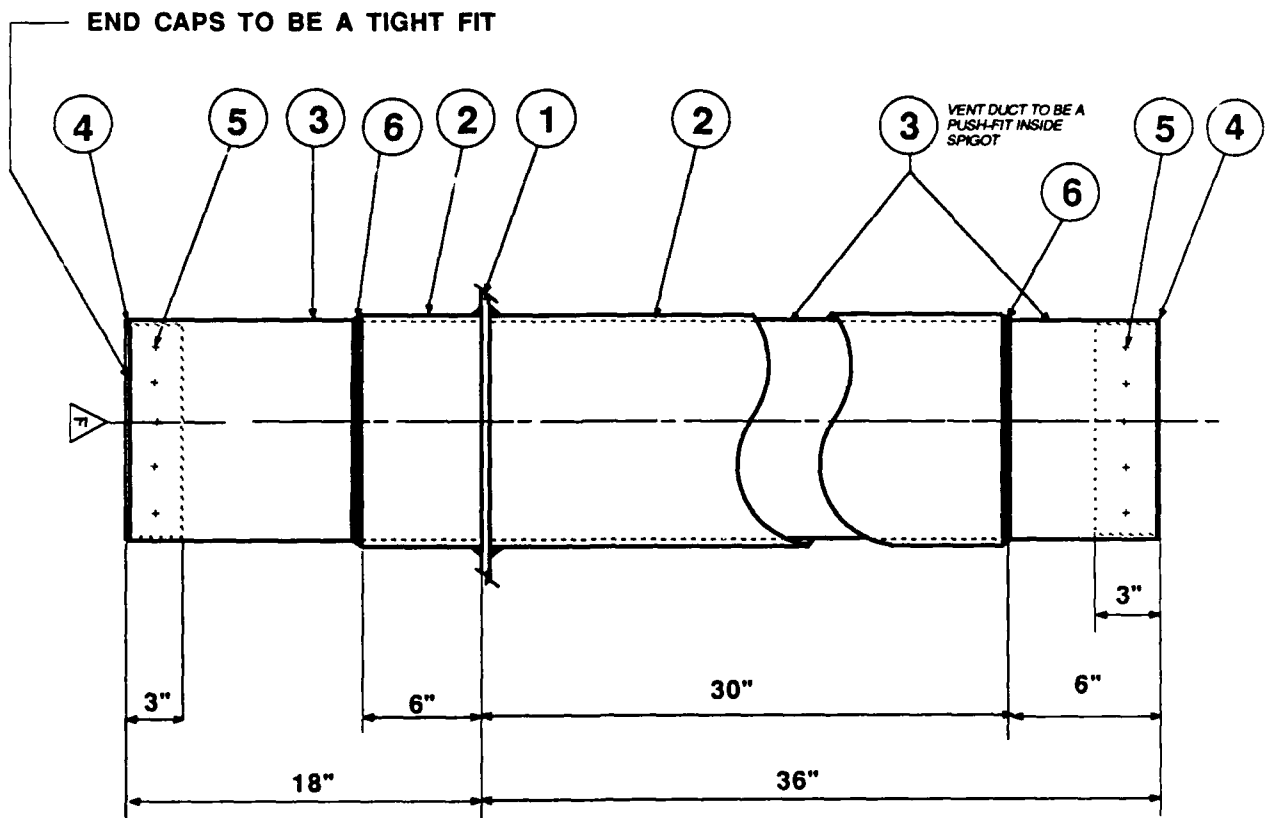
The temperatures recorded during the fire test on the unexposed surfaces are shown on ILLS. 116 through 116B.

HOSE STREAM TEST:

No water passed through the assembly during the hose stream test.

Pictorial History - Photographs were taken before, during and after the fire test.

- ① STEEL PLATE 36" X 36" X 3/16" THICK
ASTM A-53, GRADE A OR B (OR EQUIVALENT) .
- ② STEEL SPIGOT, 12-1/2" INSIDE DIAMETER X 1/8" THICK,
ASTM A-53, GRADE A OR B (OR EQUIVALENT).
- ③ 12" NOMINAL DIAMETER, STEEL SPIRAL-WOUND, VENT
DUCT (SPIRO METAL 24G OR EQUIVALENT).
- ④ STEEL INTERIOR CAP, 24G.
- ⑤ STEEL SELF TAPPING SCREWS
(12 REQUIRED PER CAP).
- ⑥ FIRE RESISTANT SEALANT



TEST SAMPLE D-26A
VENT DUCT PASSING
THROUGH STEEL SPIGOT
(RADC GRAPHIC 28)

USNC 142
ILL. 114

SAMPLE D26/A0
TEST DATE JUNE 11, 1986

| <u>T.C.</u> | <u>Location</u> |
|-------------|--|
| 1 | On penetrant, 4 in. above steel plate. |
| 2 | On penetrant, 6 in. above steel plate. |
| 3 | On penetrant, 12 in. above steel plate. |
| 4 | On penetrant, at interface of steel spigot and duct. |
| 5 | On penetrant, 18 in. above steel plate. |
| 6 | On penetrant, 24 in. above steel plate. |
| 7 | On steel plate, 3 in. from penetrant. |
| 8 | On steel plate, 4 in. from penetrant. |
| 9 | On steel plate, 4 in. from penetrant. |
| 10 | On steel plate, 8 in. from penetrant. |
| 11 | On steel plate, 8 in. from penetrant. |
| 12 | On top of penetrant. |

USNC142
ILL. 115

U.S. COAST GUARD
 UL Test No. 11 - D26/A0
 86NK8673/USNC142
 6-11-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|-------|-------|
| CHAN(NOS.) | 1 | 2 | 3 | 4 |
| TIME | | | | |
| 0: 0 | 82.6 | 82.4 | 81.5 | 80.0 |
| 4: 0 | 110.8 | 94.1 | 86.4 | 100.6 |
| 8: 0 | 210.6 | 158.5 | 115.2 | 167.8 |
| 12: 0 | 376.0 | 293.3 | 193.4 | 247.7 |
| 16: 0 | 522.5 | 431.3 | 286.3 | 304.8 |
| 20: 0 | 624.4 | 531.5 | 364.0 | 348.7 |
| 24: 0 | 703.7 | 611.5 | 428.0 | 381.1 |
| 28: 0 | 760.4 | 673.1 | 476.3 | 401.1 |
| 32: 0 | 802.3 | 723.5 | 515.8 | 427.9 |
| 36: 0 | 837.7 | 763.0 | 549.8 | 446.3 |
| 40: 0 | 864.7 | 791.4 | 578.7 | 465.0 |
| 44: 0 | 890.4 | 818.3 | 604.0 | 479.1 |
| 48: 0 | 912.0 | 836.6 | 629.3 | 490.7 |
| 52: 0 | 927.6 | 852.7 | 646.9 | 502.1 |
| 56: 0 | 945.9 | 869.2 | 665.2 | 510.1 |
| 60: 0 | 958.7 | 880.9 | 676.8 | 520.2 |

FILE USNC142
 ILL. 116

U.S. COAST GUARD
 UL Test No. 11 - D26/A0
 86NK8673/USNC142
 6-11-86

| | Temperature Degrees F | | | |
|------------|-----------------------|-------|--------|--------|
| CHAN(NOS.) | 5 | 6 | 7 | 8 |
| TIME | | | | |
| 0: 0 | 81.1 | 79.8 | 84.2 | 84.2 |
| 4: 0 | 83.2 | 82.4 | 277.1 | 278.1 |
| 8: 0 | 102.1 | 97.0 | 647.0 | 634.6 |
| 12: 0 | 153.3 | 134.6 | 949.9 | 938.9 |
| 16: 0 | 216.0 | 185.0 | 1064.9 | 1055.9 |
| 20: 0 | 275.6 | 232.9 | 1140.9 | 1133.6 |
| 24: 0 | 325.5 | 274.1 | 1188.3 | 1192.4 |
| 28: 0 | 367.7 | 310.4 | 1244.3 | 1249.0 |
| 32: 0 | 402.4 | 339.7 | 1294.5 | 1298.1 |
| 36: 0 | 431.8 | 364.5 | 1332.4 | 1335.2 |
| 40: 0 | 456.9 | 386.9 | 1367.5 | 1372.4 |
| 44: 0 | 475.1 | 403.9 | 1400.7 | 1405.7 |
| 48: 0 | 492.7 | 418.1 | 1428.5 | 1432.0 |
| 52: 0 | 507.3 | 429.2 | 1459.2 | 1461.0 |
| 56: 0 | 521.7 | 439.5 | 1478.1 | 1478.1 |
| 60: 0 | 533.1 | 449.7 | 1496.8 | 1497.2 |

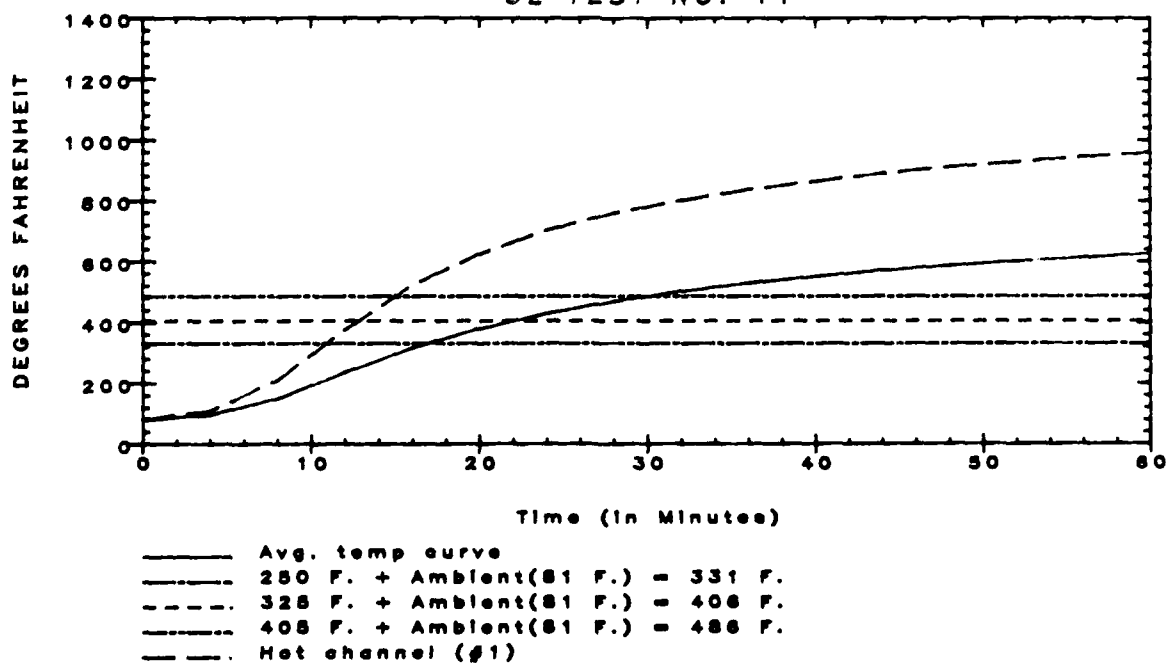
FILE USNC142
 ILL. 116A

U.S. COAST GUARD
 UL Test No. 11 - D26/A0
 86NK8673/USNC142
 6-11-86

Temperature Degrees F

| CHAN(NOS.) | 9 | 10 | 11 | 12 |
|------------|--------|--------|--------|-------|
| TIME | | | | |
| 0: 0 | 85.5 | 84.3 | 85.5 | 80.0 |
| 4: 0 | 315.5 | 254.2 | 278.1 | 125.9 |
| 8: 0 | 672.5 | 550.7 | 595.3 | 217.5 |
| 12: 0 | 925.2 | 795.7 | 830.4 | 294.3 |
| 16: 0 | 1034.7 | 925.7 | 952.9 | 337.8 |
| 20: 0 | 1104.7 | 1007.3 | 1023.7 | 365.6 |
| 24: 0 | 1156.2 | 1059.4 | 1081.1 | 387.4 |
| 28: 0 | 1212.4 | 1110.9 | 1138.3 | 405.9 |
| 32: 0 | 1262.2 | 1155.4 | 1184.0 | 424.2 |
| 36: 0 | 1313.6 | 1197.5 | 1231.7 | 430.1 |
| 40: 0 | 1346.3 | 1228.8 | 1271.5 | 441.0 |
| 44: 0 | 1380.0 | 1260.9 | 1303.7 | 454.3 |
| 48: 0 | 1405.9 | 1286.2 | 1324.8 | 464.1 |
| 52: 0 | 1431.7 | 1308.9 | 1352.1 | 472.8 |
| 56: 0 | 1449.2 | 1327.9 | 1373.7 | 480.6 |
| 60: 0 | 1466.8 | 1341.3 | 1391.5 | 489.8 |

SAMPLE D26/A0
 UL TEST NO. 11



A P P E N D I X A

PHOTOGRAPHIC RECORD

The photographic record consists of photographs of the fire side (exposed side) and the nonfire side (unexposed side) of each test sample before the fire test, photographs of the nonfire side at 5 min intervals during each fire test, photographs of the fire side and nonfire side of each sample after the fire test, photographs of each sample during the water stream test and photographs of the fire side and nonfire side after the water stream test. The photographic record was placed in three ring binders identified as Vol. 1, Vol. 2 and Vol. 3. Vol. 1 contains photographs of samples identified as D3/A60U, D4/A60E, D4/A60U, D5/A60U, D6/A60U, D9/A60U, D10/A60E, D10/A60U, D10/A0, D11/A60U, D14/A60E, D14/A60U, D14/A0, D15/A60U and D16/A60U. Vol. 2 contains photographs of samples identified as D17/A60E, D17/A60U, D17/A0, D19/A60-9U, D19/A60-6E, D19/A60-6U, D19/A60-3E&U, D21/A60U, D22/A60E, D22/A60U, D22/A0, D23/A60E and D23/A60U. Vol. 3 contains photographs of samples identified as D23/A0, D24/A60E, D24/A60U, D24/A0, D25/A60E, D25/A60U, D25/A0, D26/A60U, D26/A60E and D26/A0. At the request of the USCG, only one "Photographic Record" was obtained for the original copy of this Report. All other copies of this Report will only contain this page.